THE ANIMAL WORLD

Animal Life of Our Earth

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Highlights of Modern Knowledge

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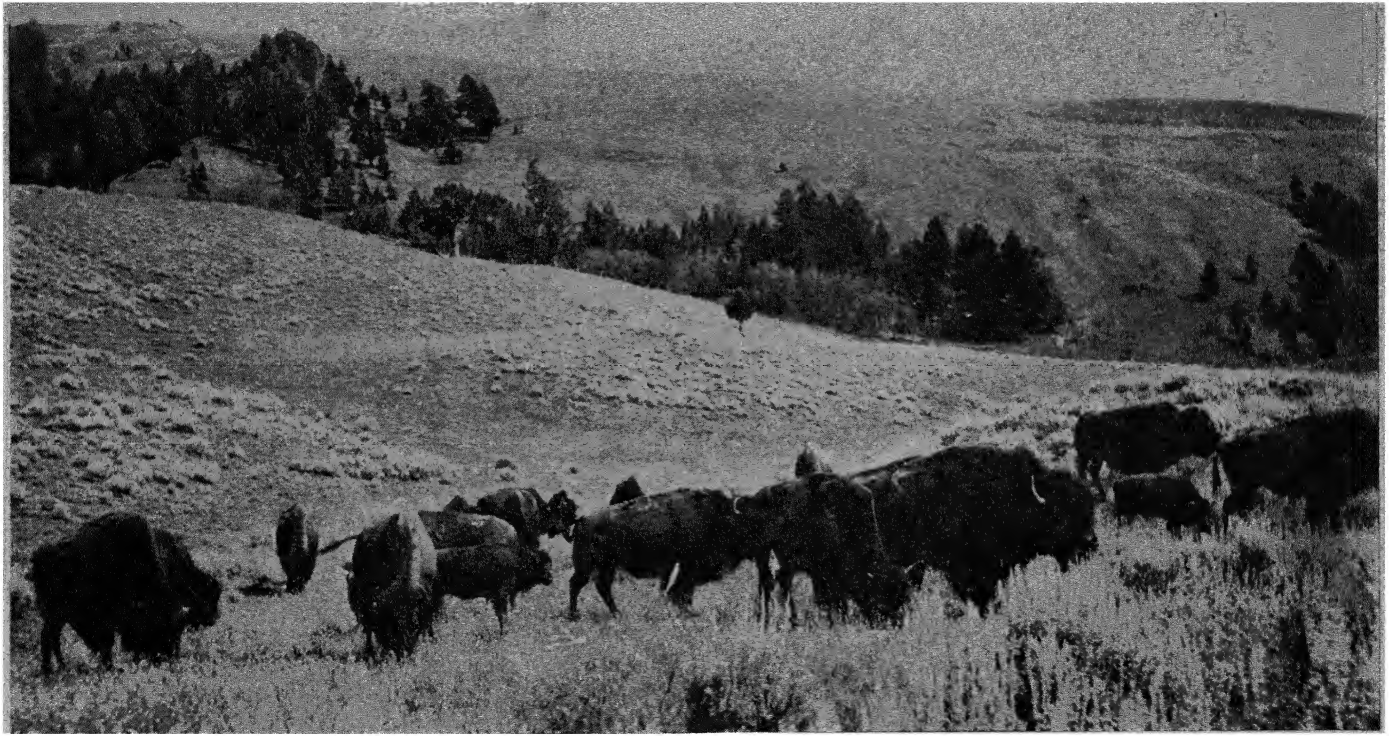
To
My Daughter
ANNABEL

Courtesy of Ned W. Frost



BUFFALO IN THEIR NATIVE HAUNTS

CHAPTER I

THE APPEAL OF THE ANIMAL WORLD

WE SHARE this world with animals. Some of them have been the intimate associates of our species since the beginning of human history. We are partakers with them in life's vicissitudes. Like them we are born and grow old and die. Like them we struggle to live and to provide for our precious offspring. Their needs are our needs—food and shelter, defense from enemies, play in youth, and work in maturity. In everything fundamental to the welfare of living beings their ways are our ways.

Fig. 1—JOHN BURROUGHS
He has just found a woodcock's nest in Georgia
From a photograph by R. J. H. DeLoach

It is because of this likeness that we are all interested in animals. We watch the antics of our pets with never ending delight. We go to the woods and try to spy out the wild animals in their homes. We go to the zoo to see strange forms from distant climes. And we watch the exhibits of trained animals and try to get glimpses of the workings of their minds.

Man in all ages has found interest and pleasure in the contemplation of the ways of animals. Their colors, their form, their motions, their habits of feeding, of fighting, of traveling, of caring for their young have always been a source of infinite pleasure. As sentient things, they have appealed to him as have

no other things in the world. They have vastly influenced the mental life of men, but in very different ways, as the store of human knowledge has grown. In the earliest times man conceived of animals as beings essentially like himself in body and in spirit. He worshiped their superior cunning; he sought to elicit their aid by wearing their claws and fangs and plumes as charms; in many tribes he claimed descent from some wild animal ancestor, and erected an image of the beast as a family totem.

Then he went to the opposite extreme and regarded himself as a different order of being, having nothing in common with the beasts. But with the growth of modern science there has come a clearer recognition of the real likenesses and differences between man and his animal associates. It has become obvious that in form and in function, in mode of development and in instinct, man has much in common with the beasts, and that on the possession of a sound animal body, maintained in health, all his possibilities of happiness and of usefulness depend.

Our bodies are obviously built on the same plan as those of some of the higher animals. When we compare them in detail we find them the same, part by part; eyes and ears, liver and lungs, fingers and toes, parts inside and parts outside, unmistakably identical down to the smallest detail! *Man is a member of the animal kingdom.* In his physical body he is a vertebrate, a mammal, a member of the group of Primates, even though in his achievements he has come to seem like another order of being.

Man's Dependence on Animal Life

The animal life of the world, of which we are a part, surrounds us on every hand, and influences all our activities. It feeds us and clothes us and works for us. It supplies us with materials for all our arts and crafts. It entertains us and educates us. Under the highly artificial conditions of modern life we may not realize this. If in our coming and going we see but a few pets in the household and a few draft animals in the streets, it is because we have segregated ourselves from the teeming life of the world and live indoors. We have committed to others the labor of getting all our necessary animal products: yet

our dependence on the animal world is none the less as absolute as though we had gathered all these products in the most primitive fashion with our own hands.

In order to understand this dependence we need go back but a little to the days of the pioneers in our own land. They were in part huntsmen, and procured food from wild nature in the form of fish and game. They were in part husbandmen, and kept a few animals in pastures and stables, protecting them from harm and feeding them and increasing and conserving their products. They were in part artisans, and manufactured these products. It is but a little while since spinning and weaving and dyeing and tanning and shoe making and harness making and cheese making and a hundred other crafts, now gone to the factories, were household arts. In that day every one knew the sources of his living, for all were partakers in the labor of obtaining or of preparing the materials of livelihood. Our needs are the same as were those of the pioneers, and the same groups of animals still supply them; but the labors of the pioneer have been parceled out among craftsmen and tradesmen of many sorts.

The Five Important Species of Animals

Animals supply us, first of all, with foods, such as meat, milk, and eggs; then with materials for clothing, such as skins, wool, and silk; and then with materials for use in our arts and manufactures, such as hair, horn, and bone. Animals draw our loads and carry our burdens. For all these aids we have found a few species eminently useful. Here in America under present conditions five species outweigh all others in their importance

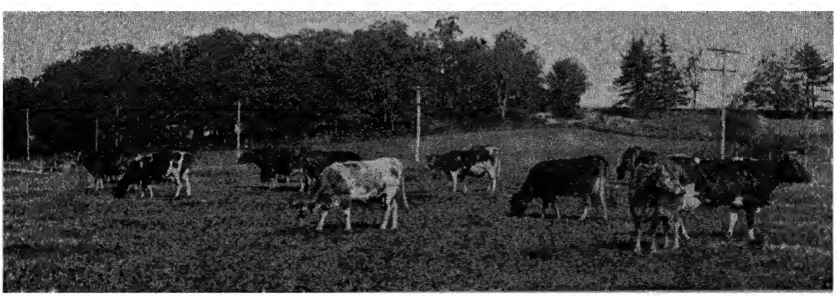


Fig. 2—A HERD OF GUERNSEY CATTLE ON PASTURE

to us. All of them were brought by our forefathers from their homes in the Old World. All of them have been closely associated with our race throughout its written history and longer, and all have had a part in the development of our civilization. We may count on the fingers of one hand those species which we have made our main dependence; they are the Horse, the Cow, the Sheep, the Hog, and the Hen—four mammals and one bird.

Though we have other domesticated animals—Goats and Donkeys, Cats and Dogs, Ducks and Pigeons, Bees and Silkworms, and others in great variety, and often locally important —there is none that can compare with any one of these five in economic value to our country at large. These five are the basis of our animal industries.

We have more names for these than for any others and this in itself is a sign of long and intimate association and economic dependence. Witness the following:

Name Collective	*Male*	*Female*	*Castrated Male*	*Immature Female*	*Young*	*Meat*
Horses	Stallion	Mare	Gelding	Filly	Colt	
Cattle Kine	Bull	Cow	Ox Steer	Heifer	Calf	Beef
Sheep	Ram	Ewe	Wether		Lamb	Mutton
Hogs Swine Pigs	Boar	Sow	Barrow		Pig Shote	Pork
Chickens Fowl Poultry	Cock Rooster	Hen	Capon	Pullet	Chick	Poultry

Five kinds out of the hundreds of thousands of different kinds of animals that dwell on the earth! Five species, domesticated in the unrecorded days of savagery and intimately associated with our race through all its history! How does it come that our living today so largely depends on these five species from the Old World? It is a long story—as long as the history of civilization itself.

CHAPTER II

MAN AMONG THE ANIMALS

Primitive Man and His Needs

Man in his primitive estate was a weak and defenseless creature. He had neither the swiftness of foot of the running beasts, nor the agility of the climbing beasts, nor the digging equipment of the burrowing beasts. He was not armed with formidable fangs or claws for fighting, nor was his body clothed in thick armor for defense. He had hands which though weak were adaptable to many uses, but his chief endowment was a mind which was able to turn the circumstances of his environment to his own profit. Lacking weapons, he made them out of wood and flint and bone and bronze and steel. Lacking coverings, he borrowed the coats of animals. Lacking swiftness, he employed the Dog to run for him and the Horse to carry him. Lacking strength, he invented the yoke and employed the strength of the Ox.

Primitive man probably dwelt in the tropics. His scanty covering of hair would indicate this. In tropical lands the supply of fruits and roots and other foods which are ready to eat when gathered and which require no special preparation is more abundant and continuous than elsewhere. Living is easier there, and forethought and provision for the future are less necessary.

Man's first needs were for food to eat and for a place of comparative security in which to dwell. Probably the earliest of his animal foods were such as are fit to be eaten as nature furnished them. Such are the eggs of birds and the soft bodies of oysters and other molluscs.

Fire—One of the First and Greatest Steps in Human Progress

One of the greatest steps in human progress came with the use of fire. Man alone of all living creatures has made fire his

servant. Its first use may have been to increase his physical comfort; to dry himself after a drenching rain, or to warm himself when the atmosphere was chill. There are animals which do these things when fire is at hand. Fire at the door of his dwelling-place in hut or cave served the further purpose of warding off nocturnal beasts of prey. Sooner or later, accidentally or otherwise, he discovered the improvement which may be brought about by the cooking of foods. This was the most important of all the innumerable uses of fire, for it vastly increased the range of available plant and animal foods. Fruits and roots and grain, fish and flesh and fowl, inedible before, with cooking became not only usable for food, but even healthful and delicious. It is the complete and universal adaptation of fire to this use that has made the word "fireside" synonymous with "home."

Fire also early served to aid in the preparation of weapons and food-gathering appliances. Earlier, doubtless, man had learned to swing a club and to hurl a stone in self-defense, but the club and stone were such as he could find in nature already shaped to his hand. Fire could be used for cutting the hardest of woods in convenient lengths, for hardening edges and points, for shaping handles, and for hollowing out vessels and even boats. Fire could be used for splitting stones; and pieces of flint thus wrought and having thin sharp edges were the most ancient of cutting instruments.

Food Preservation

Animal foods are in their natural state notoriously perishable. Most of them have their seasons of abundance and are not equally available at all times. Among savage folk, such times of plenty make for brief periods of feasting, although adding little to permanent sustenance. As forethought grew, the drying of animal foods, such as flesh and eggs, came to be practiced; drying was enormously facilitated by the aid of fire and preservation was also promoted by certain antiseptic properties of smoke. Salt, in liberal amounts, was also found to be a good preservative. The smoking and salting of meats were the chief means of their preservation before the days of cold storage.

Sea Foods

Doubtless the waters once furnished man's largest and most available supply of animal food, for in bays and on shoals there is a great abundance of edible animals which may be picked by hand. There are Oysters and Clams, needing only to be located and gone after, for they cannot get away; and there are Crabs and Shrimps and Lobsters and certain fishes which require no tools and only a little manual dexterity for their capture. A clam rake is a simple tool fashioned after the extended hand with bent fingers. Nets for taking fishes by dipping, held the slippery creatures better than hands alone.

Fishes were among the most important items of the primitive bill of fare, and one of the oldest inventions for food-gathering is the fishhook. It is also one of the most widespread, having been independently invented in many parts of the world. At first it was made of wood or bone or horn, and was clumsy and barbless; but it must have worked else it would not have been used everywhere. Perhaps it was a happy thought of some hungry savage, unable to catch the elusive fishes with his hand, to tempt them to impale themselves on a baited hook and then to quickly lift them out of the water. Doubtless the use of a barbless bone hook gave room for skill; and the catch depended then, as it does still, more on knowledge of the ways of fishes and adjustment of methods thereto, than on any little refinements of the fishing tackle.

The Invention and Use of Weapons

While at times considerable animal food might be obtained without any special apparatus for taking it, a dependable supply of the better kinds of fish and game demanded better appliances. Fish and bird and beast were too swift and too agile to be taken by hand. Even a wooden club in the hands of a hunter lengthened his reach and enabled him to bring down to earth the animal which could elude his naked grasp. He could reach farther and strike harder with a club than with bare hands. By firmly lashing a stone head to a wooden handle, a crude stone axe was made which was more efficient than a club.

A spear lengthened a man's reach very much, and equipped with a sharp point for piercing, it became an important weapon either for hunting or for defense. It was stout enough so that a man's strength might be applied to the wielding of it, yet light enough so that it could be hurled from the hand to increase its range. For battling at close range with man or beast, it was for ages the chief weapon, and it still survives for kindred savage uses in the bayonet.

But a more important weapon was the bow and arrow. This is one of the world's great inventions. Before the days of gunpowder it was used the world over. Almost every tribe of men made bows and arrows, each after its own designs, and out of its own materials. The bow was everywhere light and easily carried, yet so strong that all a man's strength might be applied through the resiliency of the bent bow to the discharge of the slender arrow. It could be used again and again, and arrows were cheaply and quickly made. But the greatest advantage of the bow lay in its increased range and accuracy. The flight of the arrow was swifter than the legs of the deer, or even the wings of the waterfowl. The arrow became fixed in our language as a symbol of swiftness, directness, and piercing power.

We do well to remember how recently these crude weapons have been superseded by firearms, and how large a rôle they have played in human progress. Man without weapons was a weakling among the beasts of the field. Equipped with the first crude products of his inventive imagination, he began to be able to cope with them. Through these he came to have dominion over them.

The Use of Traps

The use of hunting weapons doubtless tended to make the wild game more shy, and less easily approached. As the difficulties of capturing animals by direct attack became greater, man put his wits to work to get them by indirect methods. So he invented various ways of persuading animals to imprison or to execute themselves. He used many kinds of traps, snares, pitfalls, and nets. In doing this, he had to study the ways of

the animals with the utmost care. Every kind of animal had to be dealt with according to its mental aptitudes and habits. So the trapper, even more than the hunter or the fisherman, had to study the ways of animals in order to obtain a living. There

Photo by Edwin Levick

Fig. 3—A POINTER POINTING ON BIRD

was a trap or a mode of trapping for each species. It would be hard to overestimate the importance of the training and knowledge primeval man received from such pursuits.

The Dog the Most Useful of Hunting Animals

Many animals have been used by man to aid in hunting and fishing, but the Dog is the only one which has proved useful the world over. The Dog lent to man throughout the earlier stages of civilization the inestimable aid of his swiftness of foot, his keenness of hearing and of scent, and his ability to co-operate in hunting. Throughout that longest period of human history when hunting was the chief business of life the Dog was man's chief helper. He alone of all hunting animals would lead his master to the quarry, help with the taking of it, and then willingly yield all of it over into his master's hand. He alone could be taught an infinite variety of hunting tricks and methods. The Cat or Ferret would hunt the vermin of the household, but only in his own way and to satisfy the demands of his own selfish appetite. The Falcon would fly aloft, and by his actions in the air indicate the location of game, but was useless in the taking of it. The Cormorant would catch fish which might

come into the hands of his master, but only when a narrow ring was put on his neck to keep him from immediately swallowing them. Certain of the Carib Indians used the Sucking Fish (Remora) to capture other fishes for food. They sent the Remora into the water tethered with a long cord, and when by means of his powerful sucker he had attached himself to the side of another fish, they drew both ashore, killed the food fish and released the Remora to repeat the operation. All these animals worked for man about as the Fishhawk works for the Bald Eagle. That is to say, they work for themselves and man takes advantage of their labors. The Dog alone works for man cheerfully and disinterestedly. He alone is a partner.

Courtesy of Ned W. Frost

An American Black Bear

Hunting With Fire

Fire is used in hunting both to attract with its light and to drive with its heat and its smoke. Some fishes and crustaceans and game animals are attracted to a bright light at night in the same way as moths are to a candle. So true is this of fishes that, in the interest of their preservation, fishing with a "jack light" is now generally forbidden by law. The Indians were accustomed to go fishing on the Chesapeake Bay at night with lighted torches held above their canoes. It was easy fishing. The fishes would

jump toward the light and fall into the canoe. It is said that sometimes the Indians were compelled to put out the light to avoid the swamping of the boats from the excessive weight of the fishes taken. Lights were used also for getting deer within the range of their weapons, and for inducing wild water-fowl to fly against their outspread nets.

Smoke was used to drive animals. It was used to drive Bees from their honey; to drive Bears from their caves; to drive many of the lesser fur-bearers from hollow logs and trees. When a prairie or a forest burns, heat and smoke and the sore peril of fire combine to drive out both birds and beasts in a panic. Seeing this, the Indian was wont to set fires in his own way. He would surround a herd of Bison or other game with fires and drive them into corrals where they were at his mercy. Mason says: "The Digger Indians of California employed fire in corraling Rabbits. In doing this they obtained large quantities of Grasshoppers, the fire having merely singed their wings. As the squaws picked up the insects they crushed the head between the thumb and finger to kill them, and then tossed them over their shoulders into their conical baskets. These were used for food."

Other Hunting Methods

Most of these different modes of providing animal food for the family larder are familiar to us because they are being used in our own day by nearly every boy who grows up on a farm or in the country. They are practiced alone and in innumerable combinations. Smoke is used to drive a Raccoon out of a log either into traps set at the entrance, or into the jaws of hunting Dogs, or into the range of the hunter's weapons. A vast array of hunting and fishing accessories are used, most of which have come down to us out of the prehistoric past—decoys and blinds, snow shoes and ice creepers, and many means of transport of game.

There were often occasions of abundance of animals of which the primitive hunter could take advantage. Such were the swarming time of Bees, when well stored bee-trees could easily be located; the spawning time of fishes, when the shoals

were covered with them and when they could be easily approached; the times of migration of the wild Pigeons, when the acorn-bearing woods swarmed with them; the times of the migration of the waterfowl, when every watercourse was filled with them; the times of drought, when fishes were impounded in the pools of the disappearing streams; the times of floods, when land animals were marooned on islands; the times of storms when Whales and large fishes were stranded on shore; the times of encrusting ice, when Partridges and Quail were frozen in their coverts; the times of deep soft snows, when Rabbits and other quadrupeds could be run down afoot. The learning of all these things was the most important part of an education in that day when man's living was produced by nature wholly without his aid.

CHAPTER III

HUNTING AND HUSBANDRY

FROM the methods of getting a living outlined in the preceding chapter man did not come at a bound to the habit of rearing and caring for animals to increase their product. Animal husbandry had its humble and far-off beginnings in the days of savagery. Some plants were cultivated and some animals were domesticated even then. The red man in America, though he had no domesticated animal save the Dog, still practiced a sort of crude husbandry. He improved the forage for the wild deer by annual burnings that kept open the grass-covered glades in the woods. He killed off their enemies wherever possible, but he refrained from over-killing, and thus left stock to breed and renew the supply. He burned the prairies and the marshes regularly to improve the grazing. That he did not go farther and become a herdsman may have been because of the lack of animals capable of domestication; at least it is true that we have done no more as yet with such animals as were available to him.

Fig. 5—LLAMAS

From a photograph by Fannie Jacobs

Southward in America, in the isolated plateaus of Mexico and Peru, where a sort of civilization had grown up, more progress had been made; in the former the Turkey and the Pec-

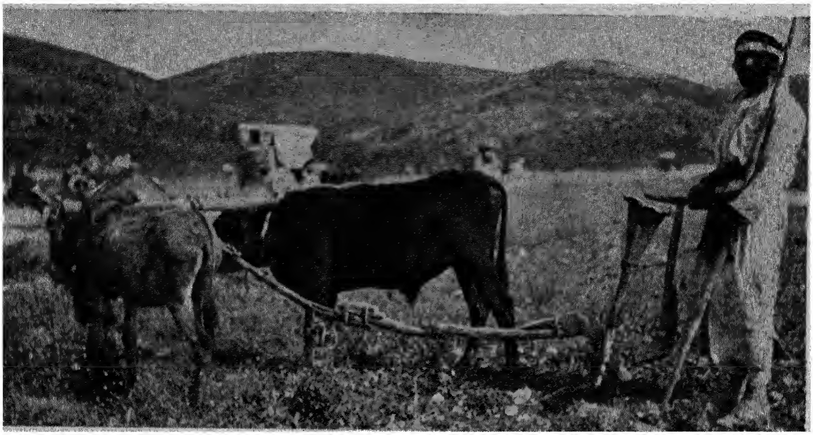


Fig. 6—AN ARAB PLOWING WITH HIS ANCIENT CROOKED STICK

cary had been partly, and in the latter place the Llama and the Guinea Pig had been wholly domesticated.

Domestication of Animals

Our debt to the days of savagery we must acknowledge when we realize that the domestication of all our valuable species of live stock antedates all our oldest human records. It seems a bit strange that the primitive peoples of the earth should have so thoroughly explored their environment and so thoroughly tried out its valuable products that with all our boasted modern advantages we have not been able to add materially to what they did in the way of domestication. The natives of every clime had selected for food and shelter and clothing and for their simple arts the best species their land afforded.

It is a singular fact that the animals which have most influenced the development of our civilization first lived with our Aryan ancestors upon the plains of the continent of Asia. Probably they first came into close association with mankind by being captured young and brought into the settlement as pets, and as playmates for the children of the household. But,

unlike most pets taken in from the wild, they were, when fed and given protection, content to stay there. In the last analysis it was their mental characteristics which determined their availability for domestication. They could be managed. They would feed by day in grassy places near at hand and return at night to the protection of the camp. Serving in times of scarcity as supplementary food supply, they came to be valued as a resource, and provision was made for their welfare. When some reared their young in captivity, their domestication was really established. Herds were started and dependence began to be placed on the supplies of meats and milk and eggs which they could furnish, rather than on the game which could be gathered from the wildwood. Thus property in live stock began, and thus the general welfare began to be established upon a new basis.

Exploitation and Agriculture

All the ways man has ever found of getting a living from nature may be reduced to two categories: *exploitation*, or living on what nature produces unaided; and *agriculture*, or living on the increase of her products which is brought about by care and cultivation of them. This applies to plants and animals alike. Both were first used in their natural state. Ripe fruits and edible roots were available for immediate use as were eggs and oysters. Better supplies of food of both sorts were made available by the use of fire for cooking. And the present day staples of both came into general use only after long ages of dependence on other foods. The arts of exploitation are hunting, trapping, and fishing. There is one art of agriculture, and it consists in aiding nature to increase the supply of those of her products which are most useful to us.

Clothing

The arts of exploitation may have developed in the tropics much as in other parts of the earth, but agriculture must have developed in temperate climes where if man were to live at all he must needs exercise foresight, and make provision for tiding himself over the long, lean winter season. Necessity has been,

indeed, "the mother of invention." To keep from starving, man had to find long-keeping foods. To keep from freezing, he had to clothe himself. He soon came to depend less on perishable fruit and roots, and more on the cereal grains: less on molluscs, and more on the flesh of land mammals and birds. He learned at the same time the arts of preserving their flesh and of using outer coverings to clothe himself. He borrowed the warm furry coats of the Fox, the Wolf, and the Beaver. Later he learned the arts of spinning and weaving and then he could use the hair of the Goat and the wool of the Sheep to make himself garments which were more adaptable and more sanitary.

Pack Animals

Even under the most primitive conditions of life there were burdens to be borne. Hence it was natural that, when animals as strong as the Ox or the Ass were companions on a journey, their strength should be used to help carry the loads. Shifting a pack to the back of the beast and strapping it there for a journey would call for no great measure of inventiveness. So we find that in many lands where animals suitable for burden-bearing were found they were impressed into this service. Such were the Elephant in India, the Camel in the desert regions of the Old World, the Llama in the Andean uplands, and the Horse and the Ass in the lands of our Aryan ancestors. These animals were the first agencies of commerce. Where steam and electricity have not yet penetrated they still carry the world's freight. One of these, the Ass or Burro, being hardy and surefooted, is especially adapted to rough mountain roads. Two others, the Horse and the Elephant, are able to carry a man with considerable speed, and have been used extensively in warfare.

Agriculture and Animal Power

Agriculture began with the cultivation of a few wild food plants. The first may well have been edible roots, since the beginning of their culture would call for no great inventiveness, the planting of a root being a process not very different from the digging up of one. Tilling the earth with a fire-hardened stick was a slow and laborious task. Doubtless there was little

tillage until there were better tools, and not much even after the invention of the plow until the great strength of the Ox was set to draw it. Then the regular tillage of permanent fields

Courtesy of the American Museum of Natural History

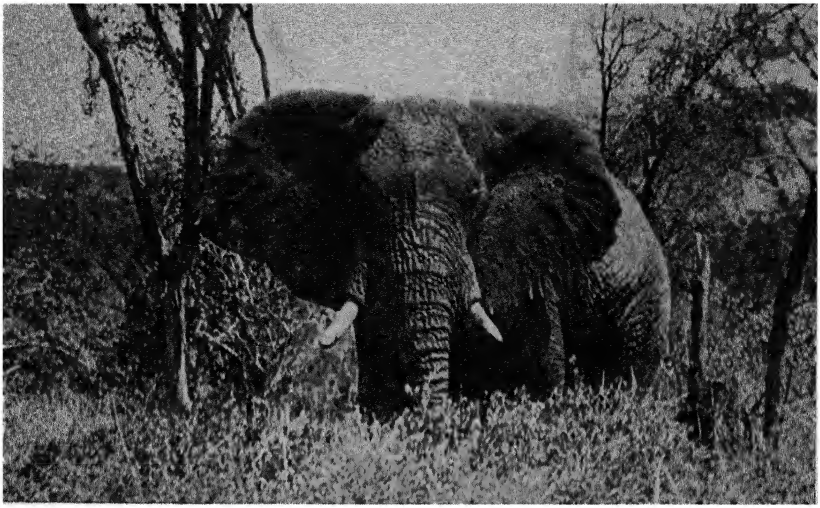


Fig. 7—THE AFRICAN ELEPHANT

From a photograph by Martin Johnson

began. Even in our own day, primitive tribes who lack draft animals prefer to clear a new field by cutting and fire, rather than to endeavor by tillage to combat the weeds in an old one.

Plow and cart are the two great complemental inventions which have done most for the promotion of agriculture, the one to increase the products of the field; the other to transport the crops; and the efficiency of both has been chiefly dependent on animal power. The agriculture that we know today had its sure foundations in the application of animal power to tillage and transportation.

The Sources of Our Knowledge of the Beginnings of Civilization

How do we know these things? Since all man's fundamental conquests of nature were made before history began to be written, how do we know anything about the beginnings of civilization? There are several sources of knowledge.

The Evidence from the Records of the Past

First, there is an actual record of the past, fragmentary, indeed, but genuine, and convincing. It consists in the relics of earlier stages of civilization, such as shells, bones, tools, pottery, and other manufactures of an imperishable sort. These have been found in the lands where our own civilization was developed, in caves which were once human habitations, in shell-heaps and kitchen middens* where discarded tools were buried with table refuse, in burial mounds, and in ancient village sites. These relics show something of how man lived in bygone ages; they show what simple tools he used, and what were his animal associates. The oldest of them show that early man in Europe was a contemporary with the Mammoth, that his companion was the Dog, that his competitor both for food and for shelter was the Bear, that his first tools were of wood and bone and flint, and that in his own ideals he scarcely differentiated himself from the brute creation. The study and interpretation of such relics of the past is the special province of the science of *archeology*.†

The Story of Primitive People

Next, there is evidence to be drawn from a comparison of existing peoples that have attained to very different levels of culture. All conditions, from abject savagery to the highest civilization yet attained, exist side by side on the earth today. There are tribes in out-of-the-way places in tropical lands, unclothed, living on what nature provides, cultivating nothing, laying up nothing, at times surfeited, at times enduring hunger, and generally satisfied. Such were the simple natives found in Haiti by Columbus, and quickly exterminated by his successors.

There are other wild tribes that practice a rude sort of agriculture, planting a little and reaping much, but living mainly by hunting and fishing. Such were the Iroquois Indians as our forefathers found them in the Eastern States, whose fields of maize, squashes, and potatoes were here and there quite

* The refuse heaps which mark the sites of primitive human habitations.
† See "The Coming of Man" in this *Series*.

extensive. There are tribes that, like the Incas of Peru, have domesticated the grazing beasts, and impressed them into service. The study and comparison of all these culture stages is the special province of the science of *ethnology*.

Archeology and ethnology tell the same story. Both tell of the humble and far-off beginnings of human culture; of crude weapons and tools of stone and wood and bone which were succeeded by others of bronze and iron and steel; of wrappings of skins which were followed by garments of textiles; of the hunter-life which was exchanged for the life of the planter and the husbandman; of pictographs and other crude efforts at graphic expression which were followed by written language.

The Evidence from Individual Cultural Development

Lastly, there is internal evidence as to the order of our cultural development to be found in the development of the individual life. Man is born, as ever, in a weak, helpless condition, out of which he passes gradually through stages which are comparable with the stages through which our civilization is believed to have passed. At first he is a freebooter, cultivating nothing, accepting the living that nature provides, and laying up nothing against future needs. When he is able to run about, he begins to plant and to feel and recognize proprietorship, he is interested in pets, tames animals, and makes them work for him. He is by nature a hunter and a fisherman before he is a farmer and a husbandman. Thus, in the individual, history tends to repeat itself and to confirm the order of evolution that is evidenced by the facts before mentioned. Just as the popular writings of a bygone age, such as *Reynard the Fox, Robinson Crusoe,* and the fairy tales, once the serious literature of grown-up folks, have become in our day the stories for boys and girls, so the ancient occupations of hunting and fishing are now the business of youth or the recreation of men seeking to renew their youth.

The Testimony of American Life

Anyone who is familiar with the history of the interior of our own country, may see in it an epitome of the economic devel-

opment of the world at large. First came the earliest of the pioneers of the Daniel Boone type, who lived by hunting and fishing, and had no domesticated animals except the Dog. Next came the early settler with a few Cattle and Hogs, which ranged the wild pastures, found their own living, and were attached to the settlement mainly through being given salt now and then and small allotments of food in storm-bound spells in winter. The early settler was also mainly a hunter; and when the killing season for his live stock came around he went out with his gun and shot them down in the open, just as he did the wild Deer.

By and by the settler developed into a crude farmer, who still hunted extensively, but who increased the size of his fields and fenced them in and raised large crops to feed to his beasts to increase their products, and built shelters for them, attaching them more closely to his home. In so doing he attached himself there, and ceased to be a wanderer on the face of the earth, and came to have a settled habitation.

Then, with increasing population and diminishing game supply, there came in, of necessity, the day of the general farmer. He ceased to depend on the open range and the highways for supplying his live stock with forage. Instead of fencing in his crops, he began to fence in his live stock, and to devote the broader areas to the raising of forage for them. He built them better shelters and provided a more adequate supply of provender; he came to depend on them almost wholly for his supply of animal food and hunting and fishing became merely pleasant pastimes. Thus in the rapid development of agriculture in some parts of America (where all the world's experience was waiting to be applied) all these stages from hunting to agriculture as a means of livelihood have been passed through within the memory of men now living.

CHAPTER IV

USEFUL ANIMALS

THAT nearly all our domesticated animals have come from the Old World is not due to absence of valuable species of like character in America. Wild representatives of the same groups of birds and mammals supplied the early pioneer and the Indian with food and clothing. Many early records attest to the exceeding abundance of fish and game and furs in America. Captain John Smith of Virginia told of killing "six, eight, ten, or fifteen Deer at a hunting." The Pottawatomi Indians of Wisconsin, "having declared war against the Bears," are reported to have killed in a short time 500 of them. The Sac and Fox Indians of Illinois in their winter hunt of 1819-1820, obtained among other things 650 Bear and 28,680 Deer skins. At the time of our Civil War, the Bison on the plains occurred in dense herds fifty miles in length, each herd numbering millions. While land was plenty and men were few in America the native pastures were well stocked. It was this abundance of wild life that drew the pioneers in America ever farther and farther westward.

The animals of most use to man are *mammals*, *birds*, and *fishes*. The most useful mammals fall in three groups: flesh-eating mammals (*Carnivora*), hoofed mammals (*Ungulata*), and rodents (*Rodentia*).

FLESH-EATING MAMMALS

Our domesticated carnivores are the Dog, the Cat, and the Ferret. Probably the Dog was the first animal to be domesticated. He certainly is the most widespread and the most intimate animal associate of man. Of all domesticated beasts he is the most companionable, the most devoted to his master's interest, the most like man in the quality of his mind. He lingered about human habitation until he came to prefer human

society to that of his own kind. During the long twilight of civilization, when hunting was the principal business of man, the Dog was by far his most efficient helper. Specialized breeds have been developed for other uses—Shepherd Dogs for guarding flocks, Sledging Dogs to assist with light transportation, Turnspits* to help with light labor, etc.—but hunting was the one occupation of man in which the Dog was pre-eminently fitted to participate. With the passing of this occupation, the Dog has ceased to be of great importance to men, but he is still the helper and companion and colaborer of youth.

The Cat and Ferret have scant value as aids in the destruction of mice and rats and other vermin, though the Cat has the merit of being pretty and cleanly and companionable.

Of native carnivorous mammals there were many fine fur-bearing species in North America. The largest were the Bears. These regularly furnished to the Indian both food and clothing. Among the scanty furnishings of the houses of the Indians, skins were of chief importance, and a bear skin was the seat of honor

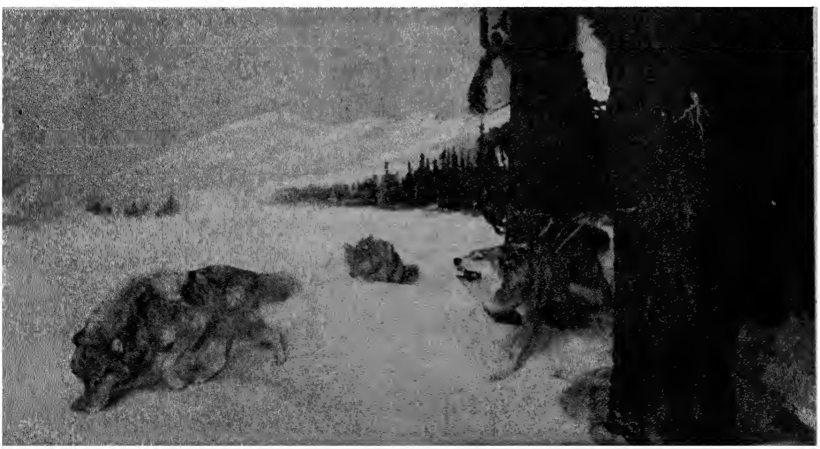


Fig. 8—THE TRAIL OF THE TIMBER WOLF
From a habitat group in the American Museum of Natural History

in the tent. Besides the Bears there were a few other wild beasts large enough to be dangerous enemies when driven to bay or when suffering hunger; such were the Puma and the Wolf.

* A breed of small dogs with long bodies and short, crooked legs, formerly used to turn spits.

All the carnivores were competitors with man for food, and he used the skins of all of them for clothing.

The wild relatives of the Dog were the Wolf, the Coyote, and the Fox; those of the Cat were the Puma, the Lynx, and the Wildcat; those of the Ferret were the Weasel and the Mink, and more remotely related — the Otter, the Sable, the Skunk, the Wolverine, and the Badger.

Fig. 9—WEASELS
From a habitat group in the American Museum of Natural History

Hoofed Mammals

The domesticated ungulates are by far the most useful of all animals whether considered from the standpoint of the aid they lend to man in his labors, or of the materials they furnish for food and manufactures.

Since the development of modern agriculture began, the most important laboring animals have been those that draw the plow and the cart. These are the Horse, the Mule, the Ox, and the Water-buffalo. The last named is chiefly useful in the rice fields of the Orient; the other three are used in all lands where agriculture is known. While other animals have been harnessed, these four do the work of the world for which yoke and harness stand. The Ox was of old the chief draft animal, the Horse then being kept mainly for pleasure or for warfare; but in our own day, the Ox is largely superseded by the Horse, which is stronger, swifter of foot, and more intelligent and adaptable. The Ass is chiefly useful to us for crossing with the Horse to produce that valuable hybrid, the Mule.

Of the domesticated beasts, probably cattle have on the whole most influenced the development of our commercial enter-

prises. Their flesh sets the standard for meat and meat products; their milk and butter and cheese in quantity surpass the yield of all other species; their hides make the best of leather, and their labor has lightened man's tasks throughout the greater part of his economic history.

Milk and milk products are the peculiar gift from cattle to man. Other mammals give milk, of course, but none other is so capable of supplying our needs out of the excess of its product. Milk alone is sufficient to sustain life; and, unlike all other foods, milk can be used by us from our earliest infancy. Cattle are the best agents man has discovered for turning the herbage of the fields into rich, nutritious, and wholesome human food.

The Goat is reared mainly in the rougher portions of our

Fig. 10—AN ANGORA RANCH

country, where it is valuable for its hardiness, and its ability to subsist on rough forage. It is developed in many varieties, some of which (Angoras) are valuable for their coats of hair (mohair). All are used for food, and in many places for milk as well. The Sheep also is very valuable for food, but its peculiar gift to us is its wool, which makes the best and warmest

of our clothing. The Pig is chiefly valuable as a quick-growing food-supply.

Of native ungulates, America once possessed many. They were the Deer, the Moose, the Elk, the Caribou, the Antelope, the Mountain Sheep, the Mountain Goat, the Bison, and the Peccary. All of them were good for food, and their skins for leather, robes, etc.

Wild Deer were of wide distribution; and venison, either fresh or "jerked" and dried, was a staple of diet. Deer skins, when tanned by methods of the Indians, made the soft leather known as "buckskin." This made the strongest of clothing and was put to a thousand other uses. The sinews of the deer were shredded and used for thread; and, before tools of steel became available, the bones were fashioned into small implements of many sorts. Fortunately the wild Deer is able to maintain itself when given a little protection, and summer visitors to our forest reserves may still see this beautiful and graceful creature.

The Bison or "American Buffalo" was the largest of the native quadrupeds. To the Indians of the plains it was all-important. It furnished them not only with food and with material for their clothing, for their tepees, and for their canoes, but with bones which they could fashion into weapons. The Indians organized hunting parties and drove the Bisons within range of their arrows, sometimes with the aid of prairie fires. Later, when they had obtained Horses from the white man, they became exceedingly skillful bare-back riders and were able to pursue the Bisons in open chase.

The Indian was a less wanton destroyer of wild animals than the white man has been. He usually killed no more than he could use. He never killed to the point of extermination, but always left some stock to breed and renew the supply. On the contrary, the killing propensities of the white hunter knew no bounds. This is well shown by the fate of the Bison. The homesteaders who went West at the close of the Civil War found the innumerable hosts of the Bison still "darkening the plains." They had no trouble killing what they needed for hides and for food. In 1869 the Union Pacific Railroad was completed across the plains making the heart of the Bison coun-

try easy of access. This brought the hunters. In a single season they cleared the territory along the railway, dividing the Bison into northern and southern herds, which never again intermingled. Even more wanton slaughter followed, and in about three years the southern herd was exterminated. The northern herd, which had formerly ranged the prairies to Saskatchewan, lasted a little longer. Ft. Benton sent 80,000 hides to market in 1876; the number rapidly decreased year by year until in 1884 there were no more to send. Almost before anybody realized that it was possible, the destruction was complete. The plains were strewn with the whitening bones of the "most magnificent of American quadrupeds." Fortunately there remained a handful, driven from the plains into mountain retreats farther westward, and these have since been gathered into reservations and are being carefully preserved.

The Bison roamed all the vast plains of North America. The members of the Deer family dwelt in the forested regions; the larger members, Moose, Elk, and Caribou, were more northerly in their range than their smaller relatives. The first American member of the Deer family seen by the early settlers was

Fig. 11—BUCK IN HUNTING SEASON
From a flashlight photograph by Mrs. Howard A. Colby

the White-tailed Deer (also called the Virginia Deer), and because of its extensive range—nearly every State in the Union—it is best known. Pronghorn Antelope ranged the foothills of the Rocky Mountains. The Mountain Sheep and the Moun-

tain Goat occupied the mountain summits. The Peccary, the American member of the Wild Swine family, was found only

Courtesy of Jack Russell, Ludlow, New Brunswick

Fig. 12—MOOSE

from our Texas border southward. In our Alaskan territory now live the Reindeer, domesticated, and the Musk-ox, wild.

The Reindeer furnishes meat and milk and skins for leather to the Eskimo besides being used as a draft animal. The Reindeer is a native of Siberia. It was introduced into Alaska by the United States government in 1879, for the benefit of the Eskimos. The Walrus fisheries, on which these natives of our arctic province were then dependent, had largely been destroyed by excessive hunting, and the poor people were threatened with starvation. The introduction of the Reindeer was an interesting experiment, and a very successful one, for the Reindeer thrived in Alaska and increased from the original importation of 500 animals to more than 100,000 and has become the Eskimos' main dependence. Previously the Eskimo was a hunter and a fisherman; now he is also a husbandman. The Reindeer is limited in its range to the north polar regions, and is superbly adapted to arctic conditions, being able to live on a diet of the frozen mosses of those treeless plains of the Far North known as tundras. The Musk-oxen live in herds of twenty to fifty head and when brought to bay by Dogs or Wolves stand facing the enemy, thus making their slaughter easy. Arctic explorers have

asserted that the flesh is excellent eating, provided the carcass is promptly and properly dressed.

Rodents

Among the rodents we find a few animals, Rats and Mice, that have domesticated themselves at our expense. Of useful domesticated rodents we have but two which are at all common, the Rabbit and the Guinea Pig. The former is from the Old World; the latter from the Andean region of South America. Both are prolific animals, easily provided with food. The raising of them requires little capital, and their economic function has been to provide an accessory food supply.

Courtesy of Ned W. Frost

Fig. 13—COMMON RABBIT

Native rodents were very numerous and all of them served the red man for food. A few, such as the Squirrels and the Rabbits, are still used for food. The quills of the Porcupine were much used by the Indians for ornament. The Muskrat of our marshes was, and still is, the most abundant of the good fur bearers.

The largest and most interesting and most valuable of our rodents is the Beaver. At the time of the coming of the white

Courtesy of the New York Zoological Society

Fig. 14—BEAVER

From a photograph by E. R. Sanborn

man it abounded in the upper reaches of most of our woodland streams. It built dams across their channels and established populous colonies. Its fine fur was very valuable, and bartering with the Indians for Beaver skins became at once the business of the frontiersman. The Dutch appropriated Manhattan Island because of Hudson's report that it would afford a fine opportunity for fur trading. The kind of fur most sought was that of the Beaver. Most of our cities were founded as trading stations, and were sustained by the sale of furs until overproduction destroyed their market value, or until the supply of available animals was exhausted, and the trade moved farther toward the frontier. When, in 1636, Springfield, Massachusetts, was founded as a frontier settlement on the Connecticut River, it was for a time one of the best points for Beaver, but after a few years the market was spoiled by overproduction, and the settlers had to resort to more prosaic and laborious means of support. So it has been with other settlements; but more often the business has thrived until no more furs were obtainable. White trappers followed, usurped the calling of the Indian, and pursued the Beaver almost to the point of extermination. That any Beavers remain is due to the fact that they are secretive in habits, and the last of them could not be found. In most of our remaining bits of wilderness a few Beavers persist, protected now by law, and in places on the far frontier there are still considerable numbers of them.

Other Important Mammals: Camels and Elephants

All our domesticated beasts have been brought to us from foreign shores; but there remain in other lands a few domesticated species which, though of very great importance there, we have not been able to use. In the desert regions of Asia and Africa there is the Camel, the "ship of the desert," a superb beast of burden, as this name implies, and wonderfully equipped by nature for making long journeys across these waterless wastes. It furnishes milk and meat, and materials for clothing, and its dried dung is used for fuel. It takes the place of cattle, sheep, and swine with us. In the land of the Incas, the Andean plateau of Peru and Bolivia, a smaller relative of the Camel, the Llama,

serves for the native Indians these same purposes, except that it does not furnish milk. It feeds upon the wild grasses of the mountain sides, and is cheaply maintained. It is capable of carrying over rough roads loads of fifty to one hundred pounds

Courtesy of the New York Zoological Society

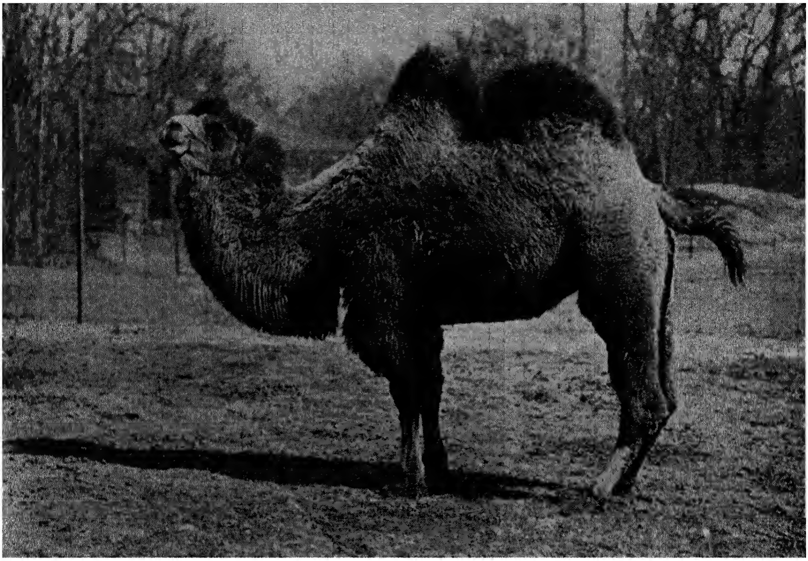


Fig. 15—BACTRIAN CAMEL

Ungainly but serviceable bearer of heavy burdens

From a photograph by E. R. Sanborn

for short distances, with frequent stops for rest. It is a graceful beast, but a bit stubborn and intractable and slow.

In India the Elephant has been tamed and put to service. Its great strength is employed in many forms of heavy labor, in transportation and in warfare. It is not truly domesticated however; it does not breed in captivity, and the supply is renewed only by capturing and taming other wild Elephants. Only the rich can own Elephants, for they require prodigious quantities of food and careful management, and are obtained only by hunting with other Elephants.

Domesticated Birds

Our domesticated birds likewise fall in three groups: the *Gallinaceous*, or *Hen-like*, *Birds*, the *Waterfowl*, and the *Pig-*

eons. Besides the common fowl, we have two gallinae of some importance—the Turkey, a native of Mexico, and the Guinea Hen, derived from Africa. We have imported and established

Fig. 16—DRIVING TURKEYS TO MARKET IN TEXAS

here European and Asiatic Pheasants, also, but more for sport than for sustenance. Of waterfowl, we have both native and imported Ducks and Geese and Swans. Our one domesticated Pigeon is the common European species.

America contributed one very fine species to the world's stock of domesticated land fowl, the Turkey. When the white man came, it was widely distributed over those wooded regions of the continent where early settlements were made. In Mexico it was already partially domesticated. It is the largest of the land fowl, and one of the finest for food. Very early it became associated with feasts, and when the Pilgrims instituted our day of Thanksgiving the Turkey was chosen by common consent as most appropriate to grace the festal board.

Wild Fowl

The Turkey was plentiful wild and there were many other Gallinaceous Birds. There was a fine series of species of Grouse distributed across the continent, beginning with the Heath Hen of the east coast, now almost, if not entirely exterminated,

and continued by the Ruffed Grouse of our eastern wooded region, the Pinnated Grouse or "Prairie Chicken" of the plains, the Sage Hen of the foot hills, and the Ptarmigan of the moun-

Fig. 17—RUFFED GROUSE RETURNING TO HER NEST
From a photograph by Charles L. Barker

tains. There were also eastern and western species of Quail; our once familiar "Bobwhite," for example, is one of them. They were hardy and prolific and comely birds which would have proved useful to us under agricultural conditions, since they eat largely insects and seeds of weeds. The farmer should have protected and preserved them in his own interests, but, instead, he has allowed them to be hunted throughout all the better farming regions almost to the point of extermination.

Of waterfowl, wild Swans, Geese, and Ducks, of many kinds were once abundant almost beyond belief in all our inland waters. During the periods of their annual migrations, they constituted a large part of the food supply of the Indian and the pioneer. They are still seen in our equinoctial skies speeding back and forth between summer breeding grounds and winter feeding grounds. Among our native wild Ducks are some of the most beautiful of living creatures. The world would be much poorer did we allow such beautiful species as the Wood Duck and the Mallard, such graceful ones as the Golden-eye and the Pin-tail, to be exterminated.

Probably no game bird of its size was ever so abundant anywhere over a large region of the earth as was the wild Passenger Pigeon over the eastern United States a hundred years ago. Now it is extinct.

Fig. 18—TEXAS BOBWHITE

From a photograph by J. D. Mitchell

Besides the foregoing, there were not a few other valuable game birds of groups no members of which are commonly domesticated. Such are the Woodcock, the Snipe, the Plover, and the Rail. Of these also there were and are many interesting and beautiful species.

Fishes

Of other groups of animals that were widely used for food, the first in importance are the fishes. A few species only, like the Carp and the Brown Trout, have been brought over from the Old World, and these are inferior to our native fishes. Some of our Basses, Sunfishes, Catfishes, Perches, and Salmons are most excellent eating. They furnished to the Indian and the pioneer their most dependable supply of animal food. All our inland waters once teemed with them. That these same waters are barren now is due to over-fishing and to abuse of the streams; they have been made unfit for fish to live in. The possible supply of food fishes in our home waters is the most neglected of our natural resources.

Other Animals

Brief as is the foregoing enumeration of the species of animals extensively cared for by man, there are but few additional remaining to be mentioned. Other vertebrate animals cultivated less generally are frogs and turtles. Of invertebrate animals there are at least two, the honey bee and the silkworm, which are cared for as domesticated species; and there are a few others, like the oyster and the lobster, which receive some care and protection on their native beds. A few others, such as

ants, cockroaches, buffalo moths, and carpet beetles, have domesticated themselves—at least they have taken to dwelling with us.

Animal Uses, General and Local

Foods, clothing, shelter, implements, and materials for the arts—these were and are the indispensable things which animals supply to human kind. In our own day modern commerce has brought the best things of all lands to our doors, and we may choose from the offerings of every clime; but of old, when our continent was peopled with warring savage tribes, more or less segregated by barriers of climate and topography, the people of each part of the continent were dependent upon the natural products of their own regions. For example, what was worn then in America was determined less by fashion and more by the demands of climate and the offerings of Mother Earth. The Eskimo encased himself in skins of Musk-ox and Arctic Fox, and crawled at night into a bearskin sleeping bag. The eastern Indian wore buckskin and beaver, and lay down at night on a bearskin. "The plains Indian could not live without his buffalo robe." The west coast red man folded about himself a blanket woven of mountain goat hair. The Incas made themselves coverings from the Llama and the Alpaca. At the south end of the continent, the Patagonian Indians wore Guanaco skins and coverings made from the plumage of the Rhea, or South American Ostrich. In the Sonoran region of Mexico babes were wrapped in robes of Rabbitskin. In the more tropical parts of the continent, where clothing was less needed, collars made of mammals' teeth and cinctures of beautiful feathers were used for personal adornment.

Animals are of service to us in four principal ways:

I. Foods
- a. Flesh
- b. Milk
- c. Eggs

II. Clothing
- a. Furs and skins
- c. Ornaments
- b. Wool and hair

III. Materials for use in the arts
- a. In a natural state: *e.g.*, tortoise shell, pearl, etc.
- b. Disguised by manufacture; *e.g.*, glue, casein, etc.

IV. Helpers
- a. In hunting
- b. As carriers
- c. As draft animals

Exploitation in Our Own Time

We live mainly by agriculture today, but we live also in part by exploitation.* The shift from a natural to an artificial basis of livelihood is a slow one, never wholly completed. Mother Nature still permits us to reap where we have not sown. The seas are too vast and too boisterous for man's puny power to control. The seas produce their vast annual harvests as in ages unremembered, and we reap and use what we can of these as of old. Mountains and deserts and polar regions go their wonted way, little disturbed by human invasions, yielding their ancient products without our toil or pains. It is only a small part of the earth's surface which we have brought under our control and made to yield the products more useful to us, and our control even here is very incomplete. Cockle will still grow with the wheat, and wild vermin still fatten in the fence-rows.

Intimacy and Control

In our dealings with useful animals there are still all degrees of intimacy and control. A few of the most important animals are gathered about human habitations. They are the daily associates of the husbandman, the constant recipients of his care. In the centers of population they have supplanted all their wild kindred and are raised in complete isolation from the dangerous beasts that were their primeval enemies. Their freedom is limited and their food is handed out to them. The life they lead is often as artificial and almost as civilized as that of man himself. At the other extreme we find places where these same kinds of animals are allowed to run wild without care or feeding, and are shot down like game in the woods.

It is but scant control which we have learned to exercise over the life of the water. Only a few of the less valuable fishes are as yet raised in ponds. Our fish foods are obtained by wholesale exploitation. We take advantage, for example, of the Shad in the Atlantic and of the Salmon in the Pacific when these run up the rivers to spawn; and then to maintain the stock, we hatch their eggs and replace their fry in the water. We trust

* See page 15.

to chance that these will be able to find a living. And as for the fishes of the open sea, we only exploit them, doing nothing whatever toward their maintenance. Like most of the other animals, they persist in spite of us and not because of us.

The Use of Furs

Agriculture has come into being because it is the most successful of all known methods of food-getting. The first and most insistent of man's necessities is food. Our important domesticated species are species good for food or species useful

Fig. 19—ALASKA FUR SEALS

From a habitat group in the American Museum of Natural History

in the labors of procuring food. Clothing has been incidental and secondary in importance. Primitive man protected himself from the rigors of cold by borrowing the coats of animals, coats that we still prize for their warmth and for their beauty. Furs are obtained almost wholly by exploitation of wild animals. Fur bearers still persist on the outskirts of our agricultural areas—by the streamsides, and in the marshes, and on the sparsely settled frontiers. Some common fur bearers, like Rabbits, Muskrats, and Skunks, are able to maintain themselves very well under agricultural conditions. Our constant hunting of them is balanced by our destroying their enemies. Being hardy and prolific and not too limited in range of food, they are able

to maintain themselves. Even the Beaver when given a little protection multiplies rapidly: it might easily be restored again to our woodland streams.

The four great staples of our fur trade today are, in the order of their abundance: Muskrat, Skunk, Raccoon, and Opossum. The furs that have figured most largely in American history, oftentimes determining the course of exploration, the place of settlement, and the nature of early civic enterprises, are still the more valuable furs of our lists: Beaver, Otter, Marten, Sable, Fisher, Wolverine, Lynx, Wolf, Fox, and Mink. Almost the only native skin which has disappeared from our lists is that of the Bison—the finest of all for the making of greatcoats and robes.

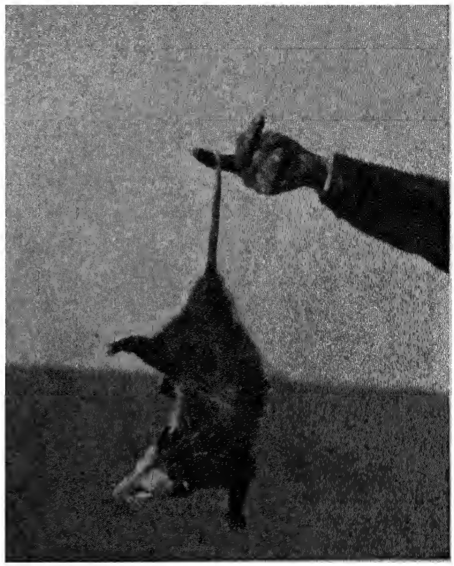


Fig. 20—AN OPOSSUM IN TROUBLE
From a photograph by J. D. Mitchell

The persistence of these wild fur bearers, in spite of incessant hunting and trapping, is attributable to the existence of lands unfit for human residence or for tillage. In swamps and stony wastes, they have been left a place to breed. Now that wet lands are being rapidly drained and put to agricultural uses, they are doomed to further restriction. With growing scarcity of valuable furs, a marked increase in fur farming may be expected. Our supply of furs, that Nature unaided has hitherto granted to the luck of the hunter, may yet be provided by the more prosaic but more sure method of the husbandman.

CHAPTER V

PLANTS AND ANIMALS

Discovering Living Things

All the foregoing is about the larger and more familiar animals. These were and are of first importance to us. But they are only a few of the animals which inhabit the earth, and interest in the others, although they are of no economic importance, has never been lacking. Our species is inquisitive beyond all others, and has sought to learn about things for the sake of knowing.

When the development of agriculture and animal husbandry had assured a more abundant and dependable food supply, relieving somewhat the severity of struggle for existence, man gained a little leisure. With means of subsistence assured, some time and energy could be devoted to exploring the world about him and satisfying his thirst for knowledge. *He began to find out more about living things.*

Likenesses and Differences

These were of two sorts, plants and animals, so very different of aspect that there was then no thought of their having much in common. It had not escaped the notice of intelligent observers that plants and animals alike present the peculiar phenomena of growth and reproduction. Both are born little and grow big, and both in maturity leave offspring to take their places on the earth. Only the living do these things. But the fixed location and seemingly inactive life of familiar green plants contrasted so strongly with the free-ranging active life of familiar animals that the early naturalists kept them quite apart in the separate kingdoms of plant life and animal life.

There were no microscopes in those days and consequently no biologists, and the simpler forms of plants and animals were

unknown. A little searching, especially a little exploration of the life of the water, revealed plants that swim freely about and animals rooted to the rocks. One may look down into the clear water of a mountain lake and see a fresh-water sponge, which is undoubtedly an animal, fixed in position, branching and tree-like in form, and green in color.

The use of the microscope brought new difficulties to the fixing of a definite boundary between the plant and animal kingdoms; for it revealed the existence of one-celled plants and of one-celled animals similar in form and alike free-swimming. It is easy to tell a pig from a pansy, but not easy to tell a plant flagellate* from an animal flagellate and when we encounter such a flagellate as Euglena (Fig. 21) which is sometimes green and plant-like and sometimes gray and animal-like, the difficulty becomes enormous.†

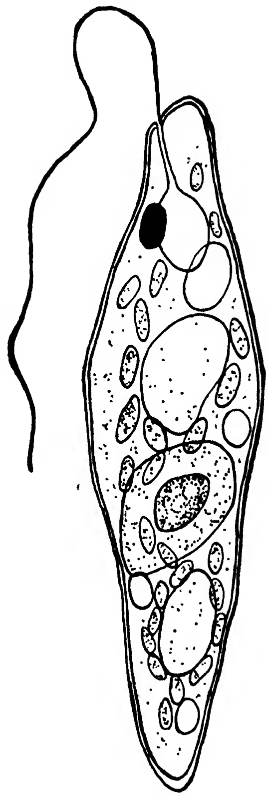


Fig. 21—EUGLENA
From a drawing by Evelyn George

All Life a Unit

Then we find that life on the earth *is a unit,* that there is no absolute difference in *forms* or in *life process,* but there is yet a broad distinction between plant and animal in the *rôles* which they play on the earth. The plant (that is, the ordinary green plant possessing chlorophyll) is able to build up living substance out of the non-living. It takes the carbon dioxide out of the air and solutions of mineral salts out of the soil and from these builds living material (protoplasm). Animals cannot do this. Animals require organic substances for food.

Such foods are concentrated and nearly all animals have developed a food sac, or stomach, of some sort for their recep-

* A Flagellate is a one-celled organism and is so named because one, two, or a very few *flagella* (singular, *flagellum*) are attached to the cell and serve as swimming organs. *Flagellum* is the Latin for "whip."

† See "The Smallest Living Things" in this *Series.*

tion. Plants, on the other hand, must find their food in diluted solutions; hence they push their branching roots into the soil and spread their leaves in the air, exposing them broadly to the sunlight. The carbon supply, which is the basis of organic stuffs, the green land plant obtains from the carbon dioxide (CO_2) of the atmosphere. Utilizing the energy of the sunlight, it breaks up this compound, releasing the oxygen and obtaining the carbon for use. Then begins the upbuilding of the two familar types of organic products, carbohydrates and proteins. When the liberated carbon is combined with the elements of water (H_2O), carbohydrates such as sugars, starches, and cellulose are formed. Further synthesis with the addition of nitrogen and other elements yields proteins. Protoplasm, the end result of this process, is something more than a chemical compound, though just what no one can say.

The Two Groups Complemental

In the world's economy green plants are thus the great producing class. They build up organic substances, storing up the sun's energy, utilizing a very little in bodily activity. Animals, on the other hand, are the great consuming class. They eat and they gad about. They take the organic substances prepared by plants and consume them, releasing their stored up energy in amazing activities. The oxygen set free by plants they recombine in respiration with the carbon of the food, returning it to the atmosphere as carbon dioxide (CO_2). Thus the two groups, green plants and animals, are complemental, each preparing food for the other and keeping the world's available food supply in circulation.

Fig. 22- AN ARMADILLO SUSPICIOUS AND LISTENING

CHAPTER VI

THE FORM OF ANIMALS

THAT animals differ enormously in their bodily parts is inescapably obvious. In the matter of legs, there are bipeds with two, and quadrupeds with four, and hexapods with six, and decapods with ten, and centipedes and millipedes with a hundred or a thousand more or less (being so numerous that they are not counted carefully); and there are worms and other animals that have no legs at all. Legs in some number are the principal locomotor equipment of most animals that live on land, as fins of some sort are for those that live in the water. Wings, however, are restricted to a few groups, mainly birds and insects.

Vertebrates and Invertebrates

The early zoologists made a simple and easy classification of animals into two groups: *Vertebrates*, or backboned animals,

Fig. 23—A WOODCHUCK
From a photograph by John T. Needham

so-called because their spinal column is composed of joints called vertebrae, and *Invertebrates*, or those which lack this structure.

Fig. 24—SKELETON OF A SALAMANDER

The vertebrates also have red corpuscles in the blood, and they do not have more than two pairs of limbs.

These are the larger, more familiar, more useful animals. Five great groups of vertebrates are known to everyone: *mammals*, *birds*, *reptiles*, *amphibians*, and *fishes*.

The Mammals

The mammals have a long period of prenatal development within the body of the mother, and are born in a relatively advanced condition. They are mainly terrestrial, though bats have taken to the air and whales to the sea. The mammals suckle their young. Their body covering is hair.

Fig. 25—A SOW AND HER LITTER

Courtesy of the United States National Museum

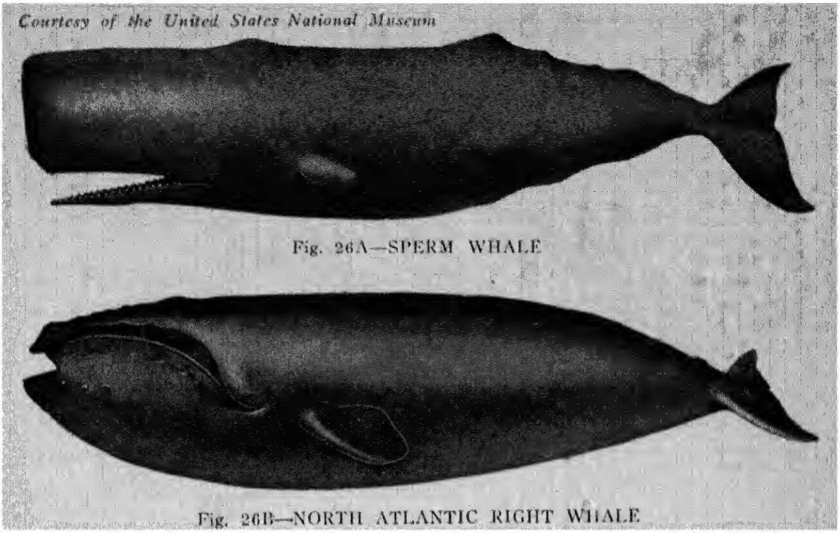


Fig. 26A—SPERM WHALE

Fig. 26B—NORTH ATLANTIC RIGHT WHALE

We ourselves are mammals. Our nearest zoological allies are the Apes, and next to these the Monkeys. The chief gift of the gods to us is a better fore brain—the central organ of a

Courtesy of the New York Zoological Society

Fig. 27—ALL OF THE GREAT APES MANIFEST A CONSUMING CURIOSITY FOR MECHANICAL OBJECTS

mind which "looks before and after," which considers cause and effect, and which is able to turn the circumstances of environment to account. Our species alters and improves its environment. Ours is the only species that profits by the gains of the exceptional individual. We are mammals who have gotten up on our hind legs to stand erect, releasing our hands from service in locomotion and allowing them to become the better servants of the brain.

The fascination of the Monkey cage at the zoo is due to the human-like behavior of its occupants. The Monkeys are full of tricks. They have unbounded curiosity. They are always playing pranks on each other. They are unceasingly active, welcoming every novel experience. They are playful and spiteful by turns. In their ways they are like growing children.

If we list the principal groups (orders) of mammals and place ourselves, as is our wont, at the head of the list, the descending series will be somewhat as follows:

Courtesy of the New York Zoological Society

Fig. 28—FRUIT BAT

From a photograph by Edwin R. Sanborn

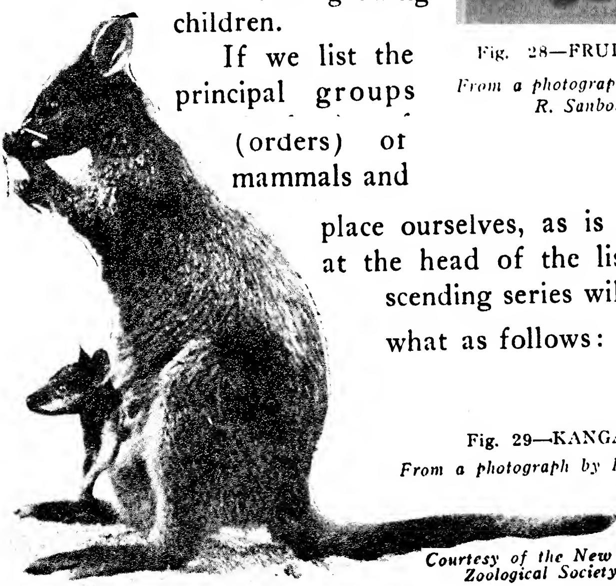


Fig. 29—KANGAROO

From a photograph by E. R. Sanborn

Courtesy of the New York Zoological Society

Orders	*Members*
PRIMATES (First Order)	Man, Apes, Monkeys, and Lemurs
CARNIVORES (Flesh-eating mammals)	Cats, Lions, Tigers, Leopards, etc. Dogs, Wolves, Foxes, Coyotes, etc. Bears, Raccoons, Seals, etc. Minks, Weasels, Skunks, etc.
UNGULATES (Hoofed mammals)	Cattle, Sheep, Goats, etc. Deer, Elk, Moose, Caribou, etc. Horses, Asses, Camels, etc. Elephants, Tapirs, Rhinoceroses, etc. Hogs, Peccaries, etc.
RODENTS (Gnawing mammals)	Rabbits, Squirrels, Woodchucks, etc. Beavers, Muskrats, etc. Rats, Mice, Conies, etc.
INSECTIVORES (Insect-eating mammals)	Moles, Shrews, etc.
BATS (Flying mammals)	Bats only
CETACEANS (Hairless marine mammals)	Whales, Porpoises, and Dolphins
SEA COWS (Water mammals)	Dugong and Manatee
EDENTATES (Toothless mammals)	Sloths, Armadillos, Ant-eaters, etc.
MARSUPIALS (Pouched mammals)	Opossums, Kangaroos, etc.
MONOTREMES (Egg-laying mammals)	Duck-bills and Echidna

We have not space to characterize these groups, or even to name all their principal component members. All this may be learned from any good textbook on zoology. Suffice it to say here that at the foot of this list stand the more primitive mammals. Of marsupials, whose young are born in a very immature

condition and are nurtured for a time after birth in a flexible pocket or pouch (*marsupium*) in the skin of the abdomen of the mother, we have only one species in the United States, the common opossum of the South. The kangaroo of Australia is another familiar type. Of the still more primitive monotremes, we have none at all. Only a few species of these are known, and all are in the Australian region. The females lay eggs which are hatched outside the body and the milk glands are very rudimentary. These lowly mammals show certain affinities with reptiles.

Courtesy of the New York Zoological Society

Fig. 30—DUCKBILL
From a photograph by E. R. Sanborn

Birds: the Feathered Animals

Birds are easily distinguished from all other animals, for all birds have feathers and no other sort of animal has feathers. The mouth is armed with a beak, and is toothless, the tail is mostly composed of feathers, caudal vertebrae being greatly reduced and modified to support the tail feathers. Birds are bipeds, they stand on two feet, having the fore limbs developed as wings. The entire physical organization of birds (excepting a few birds at the foot of the series) is expressly adapted for flight. The body is shaped to stream-line form. The wings are broad and light and strong, and the flight muscles are enormously developed. The skeleton is a model of strength and lightness. The lungs are surrounded by supplemental air bags, some of which extend into the cavities in the long bones. Respiration is thus facilitated, and body temperatures get much higher than in mammals. Birds are the most active of vertebrate

animals. They dominate the air, as mammals do the land, and fishes the sea.

Birds range in size from Hummers smaller than one's thumb to Ostriches which will carry a man riding astride. They fall into many groups that we have not space to characterize. Best known of these are the *passerine* or sparrow-like birds — song birds in general — Thrushes, Warblers, Wrens, etc.; *raptorial* birds, such as Hawks and Owls; *gallinaceous* or scratching birds, such as Grouse, Turkeys, and barnyard fowl; *waterfowl,* such as Ducks, Geese, and Swans; *wading birds,* such as Snipe, Plover, and Avocet, and many others.

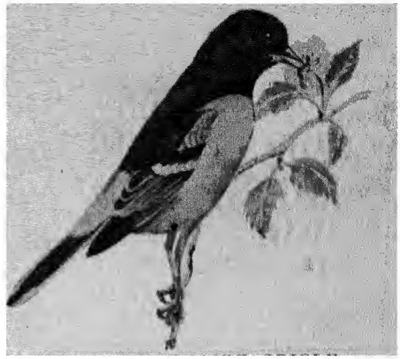


Fig. 31—BALTIMORE ORIOLE
From a drawing by R. I. Brasher

All these are flying birds, with a high keel on the breastbone for the attachment of wing muscles.

There are a few flightless aquatic birds like the Penguins which are superb swimmers. There are a few running birds, incapable of flight, which have a flat breastbone and weak wings, such as the Ostrich, Emu, and Cassowary.

Birds in their own way stand quite as high in grade of organization as do the mammals. The upper brain is smooth; lacking convolutions of its upper surface, but the hind brain (cerebellum) is more highly developed, as befits the chief co-ordinating center for voluntary movements in creatures so surpassingly agile. The senses of sight and hearing are exceptionally keen.

As with mammals, so with birds, the most primitive members of the group show affinities with reptiles. Indeed the oldest known fossil bird, the famous Archaeopteryx, which surely is a bird as shown by its feathers, had jaws with teeth of reptilian type, and a long many-jointed tail.

Reptiles

Reptiles are covered with scales or horny plates. They are cold-blooded* vertebrates which even in their earlier stages use

* In cold-blooded animals, the temperature of the body varies with that of

their lungs and not gills for breathing. There are four principal groups of living reptiles: *Lizards, Snakes, Turtles,* and *Crocodilians.*

The Lizards are a motley group, mostly long-tailed quadrupeds, often beautiful in form and color, and in hot sunshine sometimes remarkable for their intermittent activity. Some of

Courtesy of Doubleday, Page & Co.

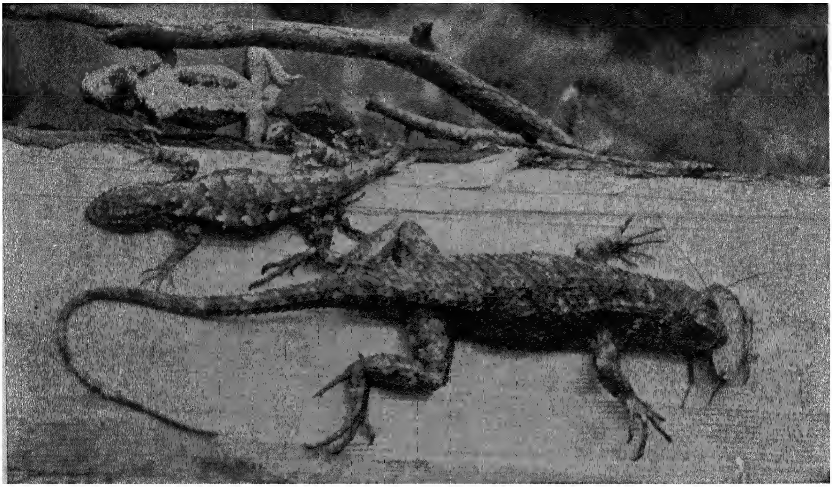


Fig. 32—COMMON SWIFT or FENCE LIZARD
From a photograph by Raymond L. Ditmars

them indeed run so quickly that they are known as "Swifts." A few of them, such as the Chameleon, can change their tints to match the color of their surroundings.

They lay soft-shelled eggs, but in a few cases the eggs are hatched internally and the young brought forth alive. Some have fragile tails, which break off when seized. A few, like the Mexican lizard Heloderma, have poison glands and somewhat fang-like teeth. One, the Horned Lizard, popularly called the Horned Toad because except for its long lizard tail it does closely resemble the tree toads, is sluggish and spiny. One, the "Flying Dragon," glides from tree to tree on a parachute of

the air or water in which they live; in warm-blooded animals the temperature is unaffected by that of the surrounding air or water. The temperature of a reptile is usually about one degree higher than its air environment; thus a Snake will have a higher bodily temperature on a summer day than on a winter day. There is a limit, however, to the amount of heat a Snake can stand, and when the air temperature approaches 95° Fahrenheit, the Snake looks for a cool retreat.

skin stretched between the tips of its laterally extended ribs. One, the Ring-necked Lizard, runs rapidly on its hind legs with its front legs held in a kangaroo-like position, and looks like a tiny reproduction of a dinosaur. One, the Slowworm, is legless, and so scaly and so snake-like in appearance as to prove that a relationship exists between the two orders of reptiles. All our native lizards are terrestrial, but many are good climbers of rocks and trees, and the house-inhabiting Geckos of the tropics can climb up smooth walls by means of their adhesive feet.

Snakes are among the most highly specialized of all animals. They represent the extreme of one long line of vertebrate evolution. They are truly wonderful creatures; but because some of them were a peril to our remote ancestors in the Old World, shunning Snakes became a matter of habit, and an age-old fear of Snakes became ingrained in our nature. This fear of dangerous Snakes was extended quite irrationally to all Snakes, and became an instinctive aversion common to all mankind and to Monkeys as well. Hence even the beautiful and agile and graceful and harmless creatures among them are not generally appreciated.

To the ancients, who did not look very closely at them, Snakes were uncanny things—their tongues darting, their movements squirming, their eyes staring, their language a hissing—fit subjects to be symbols of the Powers of Evil. The Egyptians pictured the universe as a Snake devouring its own tail, and thus making a complete circle. Its scales are numerous like the stars, its body is heavy like the earth and slippery like water. Every year the old skin is cast off and renewed as are the seasons in one eternal succession. Though lacking hands and feet, wings, or fins, it moves with incredible swiftness and freedom; *it moves by its spirit.*

Such was the Snake concept in an age that loved magic and disdained fact-finding. Any inquisitive schoolboy by a little examination of its structure can find out for himself that the Snake "walks on the tips of its ribs," that these are well supplied with muscles and are attached, pair by pair, to the freely movable ventral plates on which it creeps, and that these plates are developed in a long series beneath the body from head to tail and are set forward in rapid succession in traveling. This, combined with extreme slenderness and smoothness of body and

absence of limbs, is an admirable adaptation for getting through the grass, or other tangled vegetation.

The Snake has but one lung, with only a rudimentary stub to represent the missing one. The Snake has no eyelids and its eyes are always wide open; there is, however, a protective covering for the eye—a transparent section of the reptile's outer skin—which is shed and renewed at the same time as the remainder of its skin. This moulting occurs about three times a year.

Some Snakes lay eggs with soft but tough shells and leave them to be hatched by the sun; a Snake which is developed in an egg is provided with a temporary tooth for piercing the shell. In other species the young Snakes are fully developed within

Fig. 33—MILK SNAKE AND EGGS

From a photograph by Herbert Lang of the American Museum of Natural History

the mother's body and are born wrapped individually in their membranous sacs which are quickly burst by the little Snakes.

As in other reptiles, the Snake's teeth are for holding and not for chewing. It swallows its prey whole; and to facilitate the stowing away of larger prey, the lower jaw is very loosely put together, and the entire mouth remarkably stretchable. Animals much larger than the normal diameter of the Snake are often thus swallowed. Though getting them down is a slow and seemingly laborious process, it is doubtless a pleasant one to the Snake. The body of a Black Snake which has swallowed half a dozen eggs from a nest in the barnyard, exhibits

for a time a row of swellings suggestive of a string of beads.

Snakes range in size from a few inches to many feet in length. The Boas of the tropics, famed for their habit of coiling their bodies about their prey and crushing it to death, are the giants of the tribe. Only a few Snakes, such as Rattlers, Copperheads, Cobras, Vipers, and Moccasins, are poisonous; but these give a bad name to all the tribe. Many Snakes are useful as destroyers of Rats and Mice, and most Snakes wear beautiful coats. The colors and designs wrought in their scales are comparable with those of the most beautiful textiles.

Turtles are the heavily armored vertebrates. Their coat-of-mail consists of horny plates overlying flat expansions of the bony skeleton, with an opening at the front end for the head and forefeet and another at the rear for the tail and hind legs. The upper plate is called the carapace, and the lower the plastron. This armor is little developed in the Soft-shelled Turtles and very incomplete in the Snapping Turtles, but very complete and highly protective in the Box Tortoises. The plastron is developed in inverse ratio to the pugnacity of the animals: the Soft-shelled Turtle is exceedingly pugnacious; the Snapping Turtle, with its rather poorly developed cross-shaped plastron, will strike on the slightest provocation; whereas the Box Tortoise, possessed of a complete armor, cannot be induced to bite at all. It withdraws head, legs, and tail inside, and closes tightly both front and rear doors, and is out of harm's way.

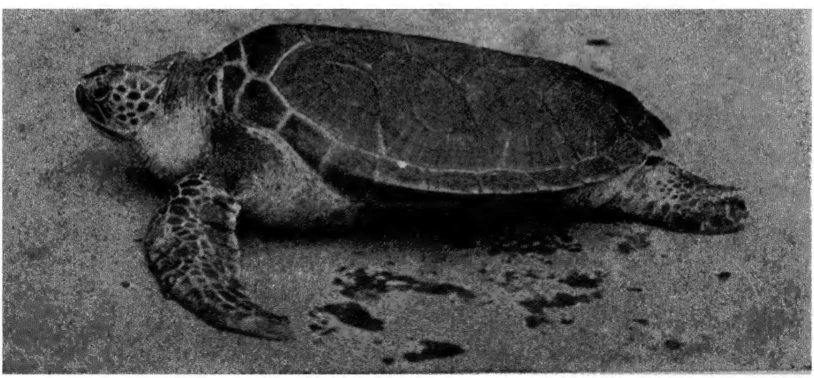


Fig. 34—GREEN TURTLE

From a photograph by Herbert Lang of the American Museum of Natural History

A hinge-like structure across the plastron permits this complete closure. With such a defense it has no need to fight, and is a confirmed pacifist. These same Box Tortoises live to great ages —greater than that of any living creatures now on the earth.

Turtles have toothless beaks somewhat like those of birds, and scaly legs and tail much like these parts in Lizards. The soft-shelled eggs are buried and left to be hatched by the sun.

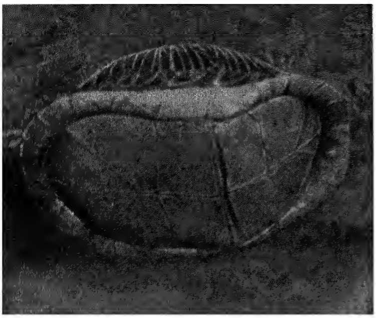


Fig. 35—COMMON BOX TURTLE WITH PLASTRON CLOSED
From a photograph by Herbert Lang of the American Museum of Natural History

Crocodilians are the largest and the most archaic in form of all our reptiles. Their tails are long, their legs are sprawling and their broad, flat backs are covered with ridged, horny scales arranged in long parallel rows. They are chiefly tropical in distribution, and two species only are found in the United States. The narrow-nosed American Crocodile is found in the southern tip of Florida, and the broad-nosed American Alligator ranges more widely in the Gulf and South Atlantic coast States. Both are inhabitants of the sluggish fresh waters of the coastal plain.

They live in waterholes in the swamps. They often lie half floating in the water with only the prominent eyes and tips of the nostrils exposed, and seize unwary birds and other animals which wander within reach. They kill such prey by drowning it; then they swallow it whole, or if too large they jerk it into fragments first. The teeth in their great jaws are very numerous and formidable. They do not use their feet for swimming but scull with their long tails. Their thirty to sixty eggs, white, oblong, and soft-shelled, they place in layers in crude nests on the shore, cover with mixed trash and swamp vegetation, and leave for the heat of the sun to hatch, but the female stays nearby and defends her eggs against trespassers.

Amphibians

The Amphibians are the naked-skinned vertebrates—Frogs, Toads, and Salamanders. In their earlier stages they are mostly

aquatic, breathing by means of gills. A few of the more primitive Salamanders live throughout their lives in the water, but most of them, and the Frogs and Toads as well, hatch into aquatic Tadpoles and come out on land at the time of their transformation. They all have long tails when young, but Frogs and Toads lose their tails in transforming.

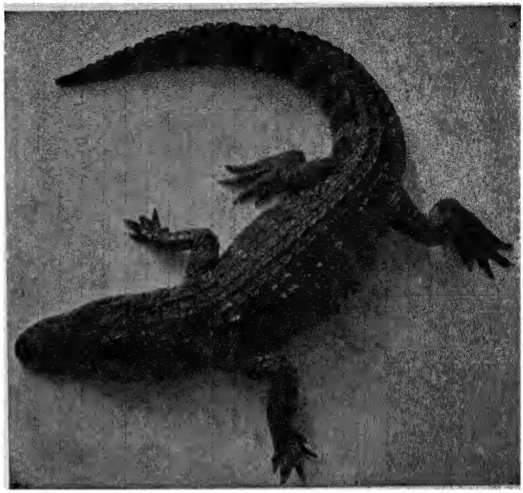


Fig. 36—AMERICAN ALLIGATOR
From a photograph by Raymond L. Ditmars

Newly hatched amphibians breathe through the skin alone until gills are developed, and in a considerable part thereafter, even after the gills are exchanged for lungs. To facilitate this the skin is kept moist by the secretions of numerous glands embedded in it. This fits it for absorption of oxygen from the air.

Amphibian eggs are large, easily procurable, and simple in type of development, consequently they are familiar objects of instruction in biological laboratories. Those of Toads are laid in strings; those of most Frogs and Salamanders in clumps of gelatine in the edges of ponds. A few oddities occur among the amphibians of South America where, in one Frog (*Rhinoderma*), the male takes the eggs into his mouth and incubates

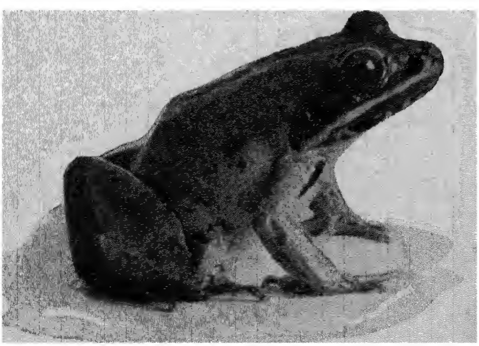


Fig. 37—WOOD FROG
From a photograph by R. W. Shufeldt

them in his capacious cheek pouches; and where, in the Surinam Toad, they are incubated singly in pits on the back of the thick-skinned female—incubated in the latter case to the adult form, there being no free tadpole stage.

The structure of the adult Frog is relatively simple. The vertebrae are few in number, but in comparison with those of other vertebrates they are wide; there are no ribs; there is a breast-bone (sternum) to which the forelegs are attached; the hind legs, instead of being attached to the sides of the pelvis, are attached at its lowest point; and both the hind legs and feet are enormous in proportion to the body.

This group illustrates well the beginning of vertebrate life on land. Hardly any of the long-tailed members of it have gotten up on their legs to walk. They slide along on their bellies, using their legs for propulsion rather than for support. And in their life histories they illustrate the transition from gills to lungs.

Fishes

Fishes are truly aquatic vertebrates which breathe by means of gills throughout their lives. Mammals, birds, and reptiles are terrestrial in origin and breathe by lungs only. The few among them which have taken to the water, range and forage there, but, with few exceptions, they make their homes and rear their broods on land. The Amphibians are of aquatic origin and at best are only partially adapted to life on land. But fishes have remained in the water, their original home, and are truly aquatic. Instead of legs for walking they have developed fins for swimming. Two pairs of fins correspond to the limbs of other verte-

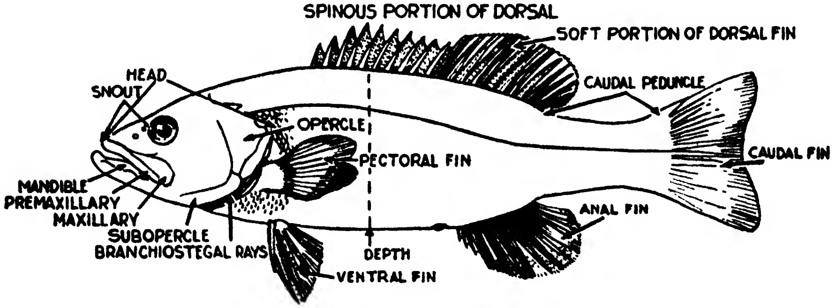


Fig. 38—TOPOGRAPHY OF A FISH

brates, and the other unpaired fins are a special gift of the gods to "finny tribes." The tail, which in most land vertebrates is a rather useless appendage—a something left over after the real

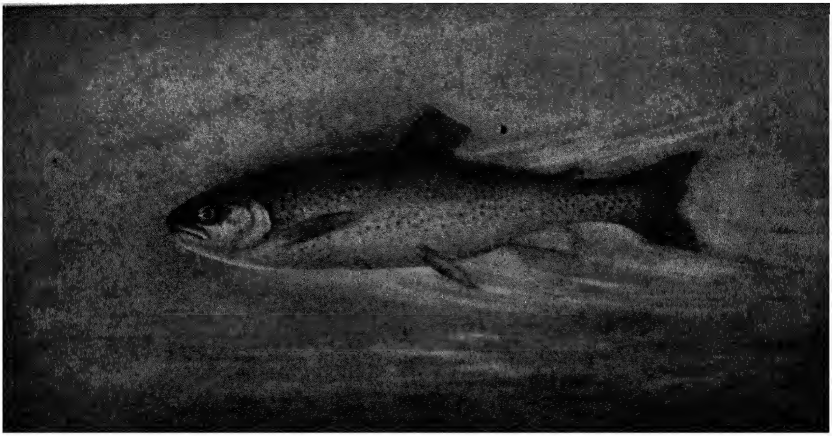


Fig 39—RAINBOW TROUT

needs of the organism have been supplied—in the fishes has become the chief organ of locomotion. It drives as well as steers.

As mammals dominate the land, and birds the air, so fishes dominate the water. They are more numerous in kinds than any of the other four great vertebrate groups. In numbers they are approached only by the birds. Like the birds they have developed in the main a stream-line form of body and superior powers of locomotion, and their dominance is probably due to their superior powers of getting about for finding food and for escaping enemies.

Vertebrate Allies

In our brief considerations of the five great groups of vertebrates we have followed the descending order (as also within each group); and if we follow this order for a little farther we come upon forms which are clearly allied to vertebrates but which have not attained to the level of these groups. Such are the Lampreys, which are eel-like in form, but which, lacking jaws and paired fins, are hardly to be called fishes. They have not a bony skeleton, and the cartilaginous brain case is partly open above. The mouth is circular (whence the group name,

Cyclostomes) and especially formed for sucking, and within its rim are numerous horny teeth arranged in concentric circles. Lampreys commonly live parasitically on our fresh water fishes, attaching themselves firmly by the mouth to the side of their victim, rasping a hole through the skin with their teeth, and sucking the blood. Our Lake Lampreys spawn in the rapids ot some inflowing stream.

Still farther down the scale of organizations we come upon the Lancelet (*Amphioxus*), a "poor relation" of the vertebrates, lacking even vertebrae. It is a slender creature about two inches long, laterally flattened, and pointed at both ends. It lives in the sand of warm sea beaches throughout the world. In place of a backbone it has a cartilaginous rod, called a notochord, extending beneath the central nerve axis from head to tail, and it has numerous gill slits on the sides of the pharynx.

Gill slits and notochord are the common possession of all vertebrates in their early stages of development. They are, therefore, the sure signs of the Lancelets' vertebrate affinities.

Gill slits and notochord are found also in the larval stages of certain other still more lowly animals that we have not space here to discuss, but only to name: *Balanoglossus, Appendicularia,* and *Salpa.* These names will serve as clues if any of our readers are interested in looking up their very remote ancestry.

Invertebrates

Before any great progress in the study of the forms of animals had been made the old classification of them into vertebrates and invertebrates became unsatisfactory. More fundamental differences in kind began to appear than the mere presence or absence of a vertebral column. When the microscope came into use and the smallest animals and the cellular structure of the larger animals began to be studied with its aid, the two major categories of Protozoans and Metazoans were recognized.

Protozoans are those animals, mostly of microscopic size, whose bodies are each composed of a single cell, or of a few loosely aggregated and relatively independent cells.

Metazoans are animals of larger size, whose bodies are each

composed of many cells, organized to operate together as a unit.

Both Protozoans and Metazoans are complete organisms, capable of maintaining all the necessary animal functions—locomotion, feeding, growth, and reproduction—but they differ in grade of organization. As the protozoans are considered in another book of this *Series,* we will pass them here with the reminder that such familiar laboratory types as Ameba and Stentor and Paramecium are fair representatives of these unicellular animals.*

All metazoans have their component cells differentiated into tissues, such as epidermis, nerve, and muscle, and the tissues combined into organs. The work of the body is divided among these mutually dependent organs. The vertebrates which we have been considering are only one major part of the metazoa.

The other metazoans differ among themselves in many respects. Those differences which have been found to be the most important for purposes of classification are: (1) Whether the body is segmented (made up of a succession of rings or joints), or not; (2) whether its symmetry is radial (like that of a cylinder—symmetry around an axis), or bilateral (like that of a triangular pyramid—symmetry in relation to a median plane); (3) whether the digestive organ is a food sac with one opening or a food tube with two; and (4) whether the paired appendages of the body are jointed.

Historically, this last distinction was discovered first; and a great natural division of the animal kingdom which is still recognized was named *Arthropoda* on account of the possession of jointed legs (*arthros,* joint, and *podos,* foot). Since in this book we are following the descending order, which in a measure is the historical order in the development of zoological science, let us next consider this group.

The Four Great Groups of Arthropods

The *Arthropods* have jointed feet (when they have any true feet at all). These are arranged in pairs on the rings of the segmented body. The horny skeleton is on the outside of the body, and the muscles are attached to its inner surface. Its

* See "The Smallest Living Things" in this *Series.*

rings have flexible membranous joinings. Its symmetry is bilateral. A food tube extends through the body from end to end; a double chain of nerve ganglia* is also segmentally arranged; and a pulsating vessel, or heart, the central organ of a circulatory system, lies on the upper, or dorsal, side of it. On this plan—the most successful of all if judged by numerical dominance—are built four great groups of Arthropods—*Insects, Spiders, Myriapods,* and *Crustaceans.*

The Numberless Insects

Insects are the most numerous group of animals on the earth today. In kinds they far outnumber all other animals put together. Their plan of organization and manner of life must therefore be well suited to the world and its conditions. That plan is a body in three major divisions—head, thorax, and abdomen—with three pairs of legs and two pairs of wings generally present on the thorax. Respiration is effected by a system of air tubes (*tracheae*) which extend throughout the body, having paired spiracles, segmentally arranged, opening to the exterior along the sides of the body. Insects are essentially terrestrial animals. They are undoubtedly terrestrial in origin; and the few which have returned to the water are only partially aquatic. As adults they all breathe free air like land insects.

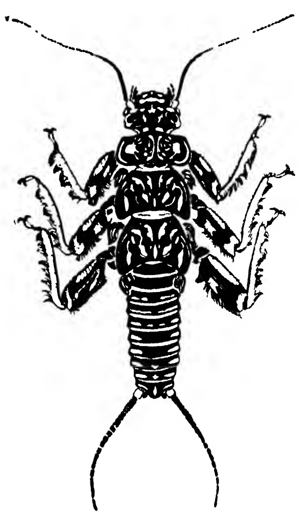


Fig. 40—STONEFLY LARVA

From a drawing by Evelyn George

A rather primitive form showing well the plan of insect structure is the Stonefly (*Perla*). The young live in rapid streams among the stones and are carnivorous. The adults fly about the watersides and, having only rudimentary jaws, do no feeding and are short lived. Their sole function is reproduction

* A ganglion (plural, ganglia) is an aggregation of nerve cells forming an enlargement upon a nerve or at the place of union or separation of two or more nerves.

and this is completed when they have mated and disposed of their eggs in the waters of their native streams.

Of similar habits are the herbivorous Mayflies and Caddisflies, all of which are likewise aquatic in their immature stages.

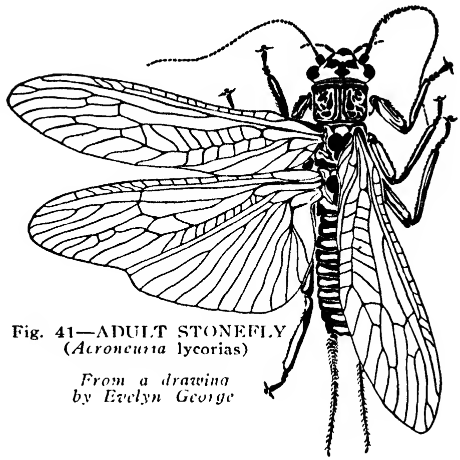


Fig. 41—ADULT STONEFLY (*Acroneuria* lycorias)

From a drawing by Evelyn George

Grasshoppers are among the best known of terrestrial insects. They are all herbivorous and they eat throughout their lives. Often when numerous they devastate fields and vineyards. Here is a bit from the Bible (*Joel* 1:6-7) attesting to the havoc grasshoppers wrought in ancient times:

> A nation is come upon my land, strong, and without number; his teeth are the teeth of a lion, and he hath the jaw-teeth of a lioness. He hath laid my vine waste, and barked my fig-trees; he hath made it clean bare, and cast it away; the branches thereof are made white.

The eggs of the more common grasshoppers are laid in pockets in the soil in holes which are dug by the female to receive them.

In one important group of insects, the True Bugs (*Hemiptera*), the mouth parts are developed for puncturing and sucking. Their lance-like channeled jaws form a tube which punctures the tissues of plants and sucks the sap out. Their work is less

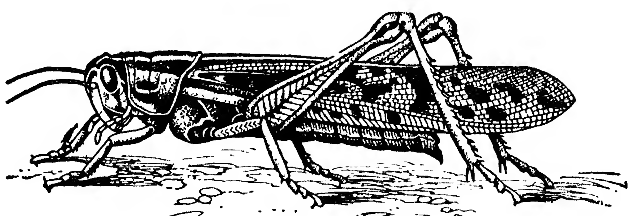


Fig. 42—SHORT-HORNED GRASSHOPPER or TRUE LOCUST

obvious than that of the chewing insects, but not less injurious to plants. In any orchard or meadow we may find hundreds of little Leafhoppers and Plant Bugs.

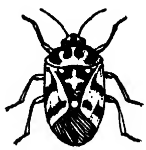


Figure 43
HARLEQUIN CABBAGE-BUG

This difference in manner of feeding between chewing and sucking insects necessitates different methods of control. Arsenical poisons sprayed or dusted on the foliage will kill the insects which eat the leaves bodily, but will leave sucking insects uninjured, because they take their food from beneath the surface. Insecticides that kill by contact or by fumes must be used for killing them.

Among sucking insects some of the worst plant pests are the smallest, such as Aphids and Scale Insects. These are individually insignificant, but they make up in numbers and in reproductive capacity for what they lack in size.

There are carnivores also among sucking insects. Some of these, like the Bedbug, are too well known. Some, like the Wheel-bug which kills Cotton Worms in the South, are beneficial.

We have not space even to mention all of the numerous orders of insects, and must leave them to textbooks of entomology, but there are four orders, the big four, of such dominant importance in the world we must at least speak of them: the order of Beetles (*Coleoptera*); the order of two-winged Flies (*Diptera*); the order of Butterflies and Moths (*Lepidoptera*); and the order of Ants, Bees, and Wasps (*Hymenoptera*). These four include the great majority of the vast insect class.

Beetles are most numerous of all. They are a hard-shelled group, having the fore wings developed as horny sheaths which together cover most of the body. These meet in a straight line down the middle of the back, and by this character beetles are readily distinguished from other insects. There are Beetles, big and little, for every habitable situation on the earth and in the fresh waters. The young of the more typical Beetles are worm-like, soft-skinned creatures commonly known as grubs.

The True Flies are two-winged as the name of their order (*Diptera*) denotes, and this alone will distinguish them from most other insects. The hind wings are represented by little knobbed, thread-like rudiments. The mouth parts are devel-

oped for piercing and sucking, as in Mosquito and Horsefly, or for lapping and sucking, as in the Housefly. This beak is retractile (capable of being drawn in) and is not at all like the stiff, jointed beak of the bugs.

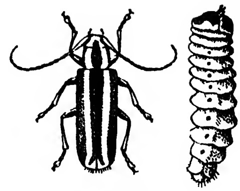


Figure 44

ROUND-HEADED APPLE-TREE BORER

Adult Beetle and Larva

In this order are many important pests. Houseflies spread the germs of typhoid fever; Mosquitos those of malaria and yellow fever; Tsetse flies those of sleeping sickness, etc. Blackflies and Sandflies bite us fiercely and Cattleflies and Horseflies torment the farmer's live stock. But there are some flies for which a good use has been found. Tachinid Flies are important parasites of destructive caterpillars and are now reared and liberated in fields suffering from these pests as a means of natural control. The degenerate worm-like young of the higher flies are known as *maggots*.

Butterflies and Moths are recognized by their complete covering of scales which rub off dust-like under pressure of the fingers. The Butterflies have knobbed antennae. In this order the mouth parts (often rudimentary) are very peculiar. They are developed as a long tubular sucking proboscis that coils up like a watch-spring when at rest and then lies concealed between a pair of rather large scaly palps.* It is adapted for extracting the nectar from deep tubular flowers for food.

The young of Butterflies and Moths are known as *caterpillars*, and are among the largest consumers of the world's vegetation.

Butterflies are mainly diurnal in their habits and Moths mainly nocturnal. Many of them are well known because their singular beauty has its appeal to collectors.

The order of the Ants, Bees, and Wasps (*Hymenoptera*) presents great diversity of appearance. It includes both winged and wingless forms. Two pairs of membranous wings with few veins in them, at least one pair of biting jaws, and sometimes a sting particularly characterize this group. The sting is quite distinctive when present, but it is present only in the

* A palp (or palpus) is a segmented process attached to the mouth of an arthropod and used for either feeling or tasting.

female of some of the higher members of the group. Moreover, it is not a desirable identifying mark, since the only way to determine afield whether it is present or not is by a rather unpleasant test.

This group represents in some ways the culmination of the insect series. Here belong the highest types of social insects.

Spiders and Their Gossamer Threads

Spiders have the head combined with the thorax and it bears a number of pairs of eyes, but no antennae. The two divisions of the body are called *cephalothorax* and *abdomen*. The former bears four pairs of legs. The latter bears lung books* for respiration at the sides near the base beneath, and spinnerets at the tip.

Silk spinning reaches its climax in the Spider group. The silken products are endlessly varied: linings to burrows, and hinges to trap doors; gossamer threads on which little Spiders flit through the air from place to place; funnel-shaped retreats with edges of the funnel outspread over the grass; and orb webs stretched across the garden paths. These last, with their radiating framework of strong dry threads and their close spiral of sticky fly-ensnaring threads, are marvels of ingenious construction and of artistic beauty as well.

Fig. 45—ORANGE GARDEN SPIDER AND WEB

From a drawing by Ellen Edmonson

Spiders are all carnivorous and they feed mainly on insects. They have poison fangs, but aside from the big Tarantulas there are hardly any whose bite is to be feared by us. They are

* A lung book (or book lung) is a sac-like breathing organ containing numerous thin folds of membrane arranged like the leaves of a book.

terrestrial but many of them haunt the waterside and a few enter the water to escape enemies. There is, however, in the allied group of Mites one order (*Hydrachnida*) which is truly aquatic.

Myriapods

Myriapods—the third great group of Arthropods—are without distinction of body regions behind the head; instead, the body is composed of a long series of uniform and freely movable leg-bearing segments. There are two pairs of legs to a segment in the Millipedes and there is a single pair in the Centipedes. The body is cylindrical in the more common Millipedes and flat in the Centipedes.

The Millipedes are non-poisonous and mainly scavengers in their feeding habits. The Centipedes are carnivorous. The latter have the tip of the foremost pair of legs developed as poison fangs, and it is with these that they "bite" or "sting" their prey. Only in a few of the largest Centipedes is the poison dangerous to man, or even painful. One very long-legged, harmless Centipede (*Scutigera*) runs phantom-like over the walls in houses. It has very long antennae on the head and fifteen pairs of legs, the hind ones extremely long and trailing far to the rear.

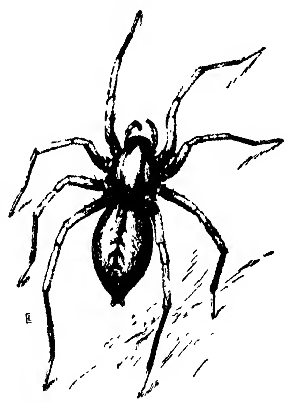


Fig 46—WOLF SPIDER

Crustaceans

Crustaceans—the fourth group—are truly aquatic Arthropods. They range in size from the huge Crabs of the ocean down to microscopic Water Fleas. They have two pairs of antennae and a variable number of pairs of feet. The form of body and manner of life is extraordinarily diverse in this group.

The most familiar forms of Crustaceans are the *decapods,* which have, as the name indicates, ten pairs of feet. The foremost are developed as "pinchers" or nipper feet and serve for grasping and for defense. They have also a strong "carapace,"

or hard shell, developed out of the consolidated segments of the fore part of the body and head. The short-tailed decapods are Crabs. The long-tailed decapods are Lobsters, Crawfishes, Shrimps, and Prawns.

There are two other familiar fresh water groups (besides many less familiar marine ones) which have fourteen feet. The *Isopods* are flat, sprawling, and slow, and live on the bottom mud, as in *Asellus,* or in moist places under boards, as in the common Pill Bug (*Oniscus*). The *Amphipods* are laterally compressed, smooth, and agile, and live climbing in tangled water weeds.

Then there is a host of smaller Crustaceans (*Entomostraca*), many of them microscopic, which we must here dismiss by saying that they are mostly free swimming in the water (a few are degenerate parasites), and that they play a large rôle in the economy of the water and are of importance to us since they are food for the young of our most valuable fishes.

Molluscs

This great branch of the animal kingdom includes Clams, Oysters, Scallops, Snails, Slugs, Cuttle Fishes, etc. However diverse the forms of these, the soft body is not segmented and it is in symmetry bilateral. It is generally covered by a thin membrane, called the mantle which secretes a heavy calcareous shell; underneath it is supported on a fleshy foot that is the single, thick, muscular, flexible organ of locomotion—proverbially slow locomotion!

The bivalves—Clams, Oysters, Scallops, Mussels, etc.—have a shell in two pieces hinged together at the back. They have no differentiated head. Two pairs of plate-like gills hang down from the body inside the shell, and a pair of siphons at the rear permit in-flow and out-flow of water for respiration. The water current also brings toward the mouth the microscopic organisms on which the animal feeds. The gills are plate-like folds of the body wall perforated for the passage of water and covered with fine hair-like processes called cilia. The steady lashing of these cilia causes water currents that bring in food and oxygen and carry out waste from the body.

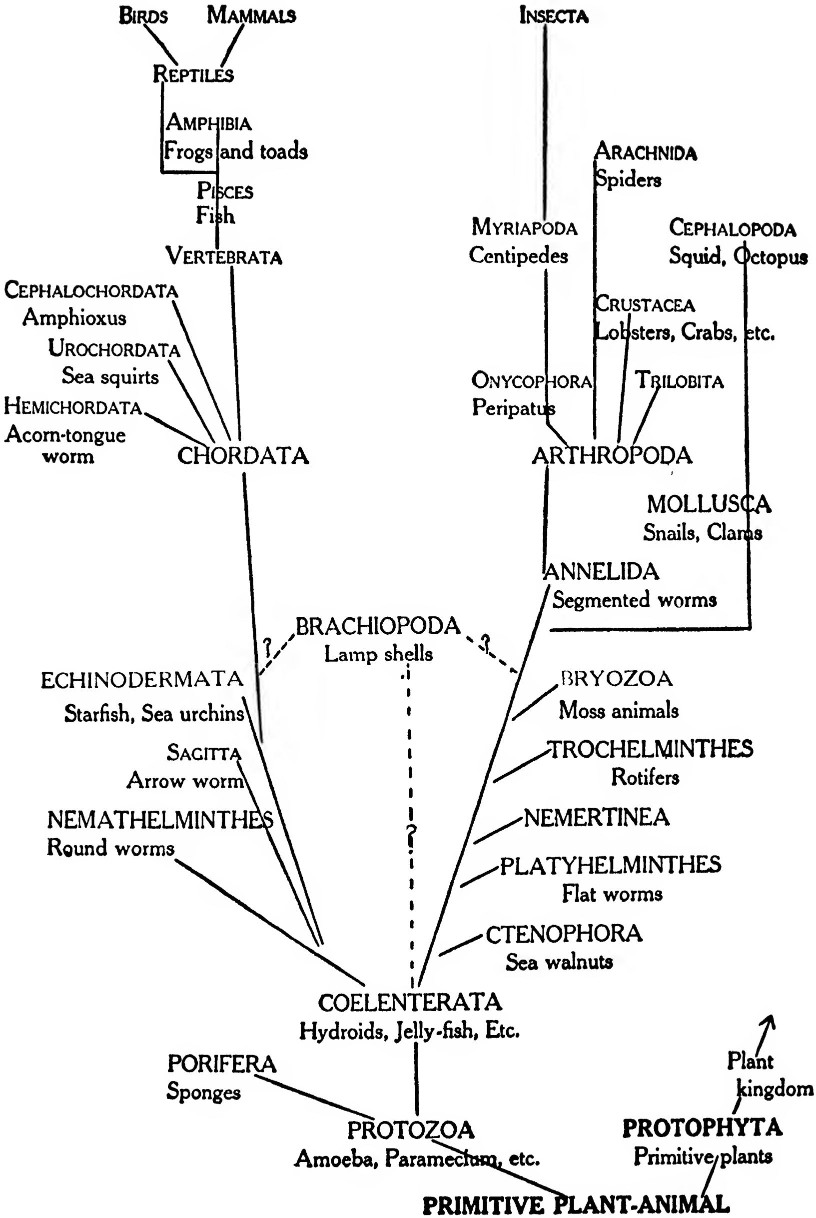
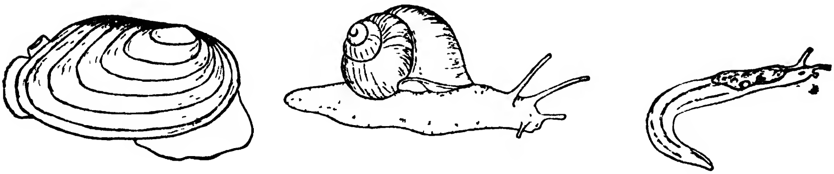


Fig. 47—TREE OF ANIMAL LIFE

Reprinted by permission from Dr. W. C. Allee's chapter "The Evolution of the Invertebrates" in *The Nature of the World and of Man* (1926); published by The University of Chicago Press

The Snails are univalves—that is, the shell is in one piece; often it is coiled in spiral form. At the front of the body there



A Clam A Snail A Slug

Fig 18—THREE MOLLUSCS

is a feebly differentiated head bearing eyes and fleshy retractile unsegmented antennae. The mouth is armed, not with jaws, but with a rasping tongue. The shell in Slugs is but little developed and hence slugs are spoken of as naked Molluscs; but in most Snails it is so large that the body, head, and feet may all be withdrawn within it. And in the River Snails the foot bears a discoid operculum, or disc-like cover, which comes in last and closes the door against intruders.

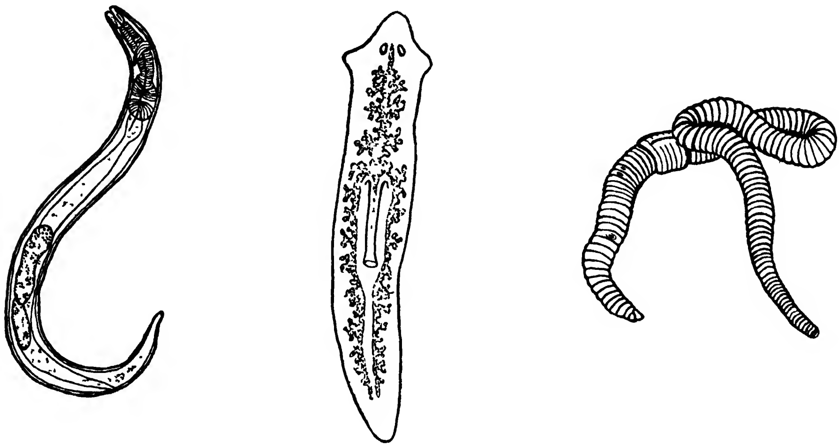
Cuttle Fishes—Squid, Octopus, Devil Fish, Nautilus, etc.—secrete no external shell and have no foot. They are all marine. They are free swimming, and they swim with head to rearward, by ejections of water. The head is well developed and bears a circle of great arms or tentacles. These are equipped with numerous sucking disks. The Nautilus secretes a beautiful thin internal pearly or papery shell known as "cuttlefish bone."

Worms

In so small a book as this we have not space for more than a mention of a few members of that heterogeneous assemblage of animal forms which has passed in former times under the loose designation of *Vermes*. Some of them, like the Earthworm, are true worms, with segmented body; others like the Rotifers and Bryozoans are not worms at all.

The true worms (including Leeches) are now grouped together as *Annulates*. The body is composed of a long series of rings or segments, as the name indicates, with little differentiation among them, and with no legs or head. There are, however,

definite anterior and posterior ends. Bristles protruding from the skin assist in locomotion. Leeches lack these bristles, but



A Thread Worm A Flat Worm An Earth Worm

Fig. 19—THREE WORMS

have a sucking disk developed at each end of the body. Leeches travel by loopings of the body, with successive attachments and releases of these disks.

Earthworms, as is well known, are terrestrial. Since Darwin's day, their work of soil mixing has been appreciated.* Most of the bristle-bearing Worms and the Leeches are aquatic, and many are marine.

Not included in the Annulates are the unsegmented groups of the Thread Worms (*Nematodes*), the Flatworms (*Platodes*), and the Tapeworms (*Cestodes*). The last are well known intestinal parasites. The Flukes are disease-causing parasitic Flatworms, and Trichina (the cause of trichinosis) and Hookworms are Nematodes of great importance.

Still less worm-like are the Rotifers and the Bryozoans. The former we dismiss with a picture of one of them. They are all microscopic, aquatic animals, often very abundant in lakes and ponds. The Bryozoans are not to be passed in a chapter on animal forms without mention of their curiously plant-like man-

* Darwin, Charles: *The Formation of Vegetable Mould through the Action of Earthworms.*

ner of growth. Bryozoans increase asexually by budding and the buds remain attached in the rear as branches from a parent stem, and secrete about themselves protective coverings. In Plumatella, the one shown in Figure 51, this covering is a brownish, protective tube of shell-like material with a live animal (*Zooid*) in the hollow tip of each branch. It grows attached flatwise to the under surface of rocks in streams. When disturbed, each animal retreats into its tube, but when extended and waving its beautiful crown of tentacles in search of food its animal nature is more apparent.

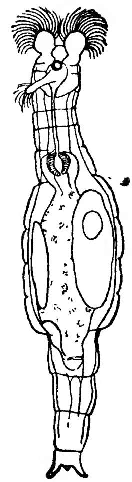


Figure 50
A ROTIFER
From a drawing by Evelyn George

ECHINODERMATES

The members of this branch of the animal kingdom—Starfishes, Sea Urchins, Holothurians, etc.—are exclusively marine. They are common enough on the seashore. They have unsegmented bodies whose parts are mostly arranged radially around a central axis. An alimentary canal extends through the body, separated from the body wall by a body cavity.

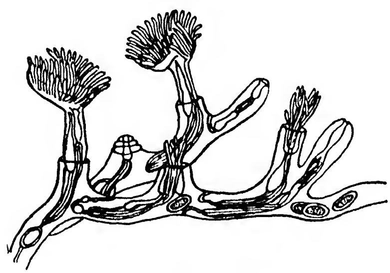


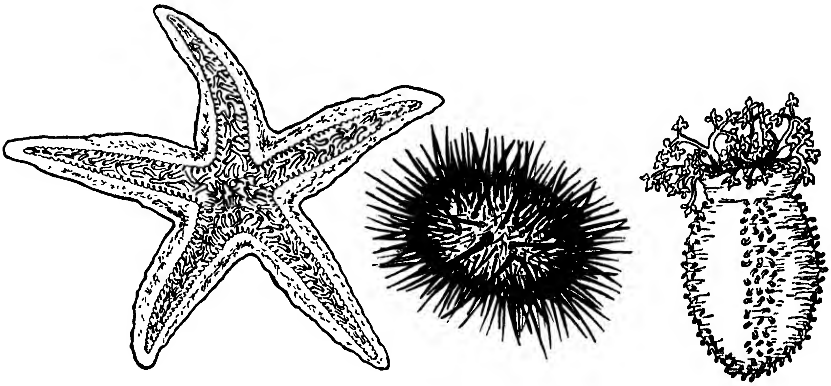
Fig. 51—THE BRYOZOAN PLUMATELLA
From a drawing by Evelyn George

Definite systems of organs are present, including a water system that is peculiar to members of this group. Water is admitted through a perforated plate to radially arranged main water tubes, and from these tubes numberless little cylindric branches called "tube feet" pass to the outside through holes in the body wall. These tube feet are retractile and end in minute sucking disks. In walking, they are first protruded and attached at their tips to some solid support; then, as they are drawn in (retracted), the body is drawn forward.

The common Starfish is five-rayed. It has a very loose and baggy stomach which can be everted out of the mouth and

wrapped around a clam or oyster outside to digest it. When the meal is over and digestion done, the stomach is reefed in and stowed away again inside.

The common Sea Urchin is more or less hemispherical and has its line of tube feet alternating with a line of movable spines,



Starfish Sea Urchin Holothurian

Fig. 52—THREE ECHINODERMATES

From drawings by Evelyn George

which also are used to some extent in locomotion. The mouth, which is underneath as in the Starfish, is armed with sharp convergent beak-like horny plates, capable of cutting up food for swallowing.

The Sea Cucumbers are more or less melon-shaped and lie on the side, on any side; for theirs is a radial symmetry. Around the mouth are fringes of variously branched tentacles.

Coelenterates

This branch of the animal kingdom is almost exclusively marine and includes the Hydroids and the Corals. The common Hydra is widely distributed in fresh water. A few Jellyfishes occur locally in brackish waters inland. They abound in all seas and even in the depths of the ocean.

The symmetry of the body is radial. The digestive apparatus is a food sac with one opening only, the mouth. There is no body cavity, and there is no system of internal organs. Tentacles radiating around the oral end of the body are the feeding organs.

Porifers

These are the sponges. Their place is at the foot of the metazoan series. They have no very definite symmetry of body and no definite organs. They are fixed where they grow, and incapable of locomotion. The body is a mass of living animal cells, together with the supporting skeleton structures which these cells secrete. They are rather loosely put together, yet to a degree organized and interdependent. Numerous pores on the surface of the body communicate by internal passageways with large openings at the summit or free end of the body. Water enters at the pores and passes out at the large opening. Its food contents of microscopic organisms is taken up by the cells along the way. There is hardly any other evidence of

A Hydra with buds A Sea Anemone A Jellyfish

Fig. 53—THREE COELENTERATES

From drawings by Evelyn George

animal activity, but certain cells around the osteole will contract to partially close it on stimulation.

Most sponges are marine. Those of most use to us secrete a horny skeleton. *The sponges of commerce are the skeletons only with all the flesh of the sponge removed.* The glass sponges build a beautiful cylindric net of glass-like strands. The fresh water sponges build a loosely aggregated skeleton of fine needles, or spicules, of silica. When these sponges grow in the light they are of a bright green color. In the shade they are yellowish. They are not uncommon around the rocks in the narrows of clear-flowing streams.

CHAPTER VII

HOW ANIMALS GROW UP

All animals come from eggs. The egg is a single cell. The story of its origin and embryonic development is told in other books of this *Series*.* Suffice it to say here that after the sperm has united with it in fertilization, nothing can come out of the egg but what is already potentially present in it. A hen

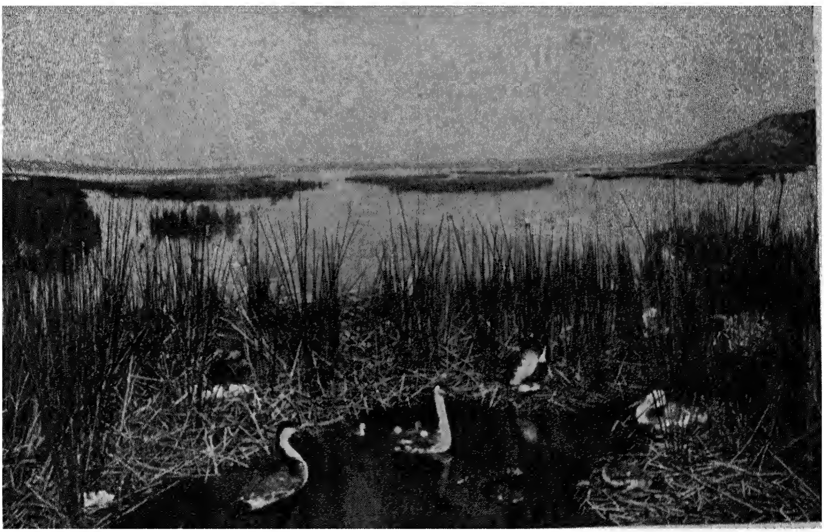


Fig. 54—A WESTERN GREBE COLONY
Crane Lake, Saskatchewan, Canada
From a habitat group in the American Museum of Natural History

by sitting on goose eggs can hatch nothing but geese out of them, for there is nothing but goose in them.

There is, however, no goose apparent in them at the beginning of their development. There is hardly more organization present than in the simplest protozoan. Thus all animals, in-

* See "The Coming and Evolution of Life," "Heredity and Variation," "The Smallest Living Things," and "The Plant World."

cluding our own species, start at a common level. The gains of all the ages each individual must in his own time re-acquire for himself. This is a fact of profound significance.

How Eggs Differ

Superficially eggs differ enormously in size and appearance. To the little bit of living protoplasm that is their essential part, there are added food for the developing young and protective

Fig. 55—GANNETS AND MURRES NESTING
Great Bird Rock, Gulf of St. Lawrence
From a photograph by Herbert K. Job

coverings. According to the amount of food material added, eggs vary in size, from those of the oyster, too small to be seen without a microscope, to those of the ostrich, which may weigh two pounds. There is a gradual increase as we ascend the scale of animal organization. Yolk added to the egg permits the embryo to grow to larger size before being ushered forth into the world to shift for itself; this is better nurture. This type of nurture culminates in the group of birds which have added yolk and then albumen and then hard shells.

In mammals we have another type of nurture. The eggs are small, so small as to be scarcely visible to the unaided eye, and they contain very little yolk. They are retained and hatched

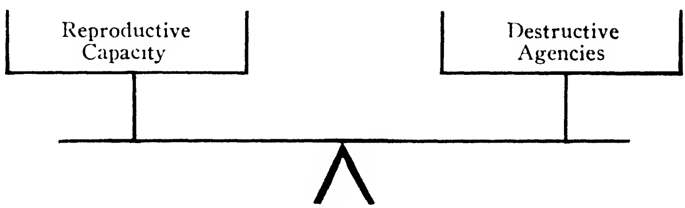
within the uterus of the mother, and the developing embryo is fed until birth from the blood of the mother through the medium of enveloping embryonic membranes. This is the culmination of physical nurture. This plan gives the young the best start in life.

The Number of Eggs

The number of eggs produced by different kinds of animals varies enormously. It varies with the needs of the species and the vicissitudes of life. The stormy petrel, which nests on inaccessible cliffs by the oceanside where few enemies come, and which derives its food from the inexhaustible larder of the sea, lays a single egg each season, whereas the oyster in the shoals of the shore, whose brood meets with enemies and casualties innumerable, lays eggs in millions. The number, whether large or small, is just enough to keep the species going and no more.

Natural Balance in the Animal World

Thus there exists in nature a relatively stable condition of society which has been called the *natural balance;* on one side of the scale are the number of young produced, and on the other, all the eliminative agencies, such as casualities, enemies, and competitors. We may represent it thus:



It is a marvelous thing that the composition of any natural society remains about the same over long periods of time with only minor fluctuations. Each component species may have its cycle of scarcity and abundance, but in the long run it holds its own, and no more, unless there be some disturbance of natural conditions, such as man often introduces. When eggs are laid, the losses begin with the destruction of the eggs and continue steadily to the end, when the survivors will number only about as many as their parents.

Changes of Form in Development

Animals which are well nurtured before birth or before hatching may grow to a considerable size, and may attain to a form much like that of their parents, before they have to stand alone, but most animals hatch in an immature form and undergo great changes in post-embryonic development. From the frog's egg there hatches not a frog but a tadpole, lacking legs, lacking lungs, lacking even a lower jaw. It has a long tail and gills and a two-chambered fish-like heart, and exhibits at first an altogether more primitive aquatic type of vertebrate structure than does the adult frog. Shortly, if all goes well, it will exchange its simple external gills for a better set, newly developed on the inner side of its gill arches. Later its legs will grow out as two pairs of buds on the sides of the trunk. Its tail will be absorbed. Jaws will shape themselves. Lungs will develop. It will appear on the shore with long, jumping hind legs as an adult frog.

There are many examples in the animal world of change of form such as this. This change is called *metamorphosis*. The earliest free-living form of the eel is a curious creature which when first discovered was thought to be an entirely different animal, and was named *Leptocephalus*. It is now called the leptocephalus stage of the eel.

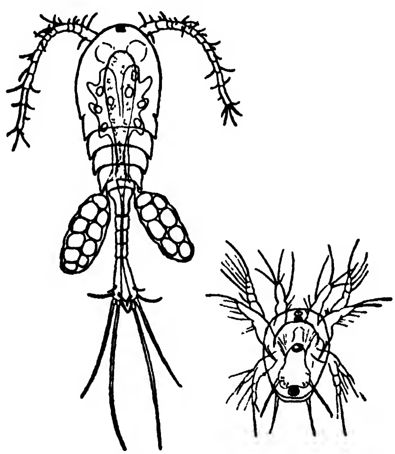


Fig. 56—CYCLOPS
Left, Adult female with eggs
Right, Nauplius or Larva
From drawings by Evelyn George

In the development of the Crab two successive larval forms were thus found, and thought to be distinct, and named *Nauplius* and *Zoea* respectively. The earlier of these, the Nauplius, is a first larval stage in the development of crustaceans of several very diverse groups. It is in all an ovoid flattish creature without distinction of body regions, and with only three pairs of appendages. This is what comes forth from the egg. Compare the Nauplius of Cyclops in Figure 56, with the adult, which

has distinct anterior and posterior body regions and ten pairs of appendages, of which the foremost are the long antennae by means of which it swims.

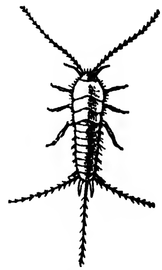


Figure 57
FISH-MOTH
(After Howard and Marlatt)

Insects furnish the most familiar as well as the most remarkable examples of metamorphosis, but it is a matter of evolution within the insect group. At the foot of the insect series stand two small groups—Springtails (*Collembola*) and Bristletails (*Thysanura*)—which undergo hardly any change of form. The more primitive winged insects, such as the Stonefly shown in Figure 40, hatch in a form not very different from that of the adult. In their growing up the chief portent of change is seen in the developing wing buds on the back. When transformation occurs and the last larval skin is cast off, the sudden enormous

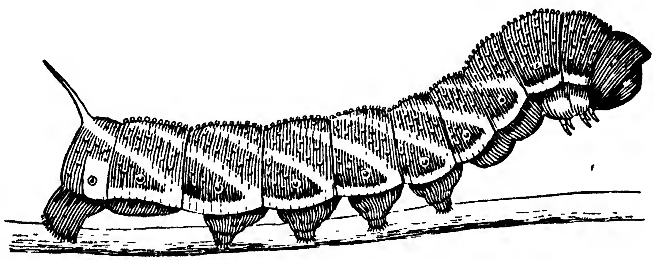


Fig. 58—TOMATO WORM, THE LARVA OF THE SPHINX MOTH

expansion of the adult wings is the chief change seen. Similar changes are undergone by Grasshoppers, Dragonflies, Mayflies, and Bugs.

Most insects, however, hatch in a worm-like form, without obvious distinction of body regions, and with greatly reduced appendages. The young of Butterflies and Moths we call *caterpillars;* those of Beetles we call *grubs;* those of Flies we call *maggots.* All these differ remarkably from their corresponding adults, not only in structure, but also in food and shelter requirements, in powers of locomotion, and in every detail of manner of life. The caterpillar gorges itself with leaves, moves slowly by

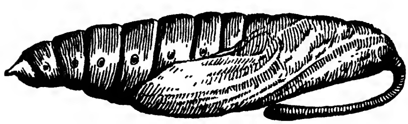


Fig. 59—TOMATO WORM PUPA

creeping, spins silk, and sticks closely to its one food plant, but the Butterfly which comes from it is an agile aerial creature flitting from flower to flower and sipping nectar.

So great is this change from larva to adult that in all the higher insects an intermediate stage has come in for the making over of the one into the other; a quiescent stage called the *pupa.* The caterpillar when grown, goes into retirement, spins up (oftenest in a cocoon of silk) and rests. It slips off the old larval skin and becomes a *pupa,* or *chrysalis.* Wings and legs and other appendages which have been developing beneath the old larval skin now appear externally, but they are not yet ready for use. Extensive changes go on internally until the parts of the larva have all been made over into the adult form. At the final transformation, out of a rent in the back of the pupal skin, emerges the Butterfly or Moth; at first limp and pale, but soon becoming brisk and fully colored, and ready for its first flight.

A pupal stage is present, and similar changes occur in Bees and Flies and Beetles. The Hellgramite, which is also called the Dobson Bug, the Crawler, the Hell-devil, the Conniption Bug, and the Arnly Bug, is the larval stage of the Dobson Fly (*Corydalis cornuta*). This larva is found under stones in streams, and is much sought after for bait for bass-fishing. When the Hellgramite is about three years old, it leaves the water and pupates under stones, in decaying logs, or in the earth. Several weeks later the adult fly emerges.

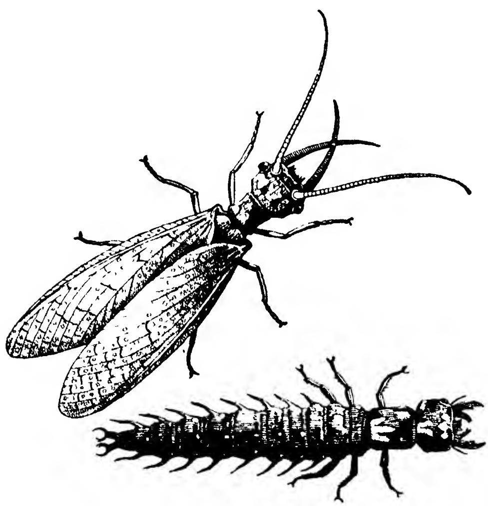


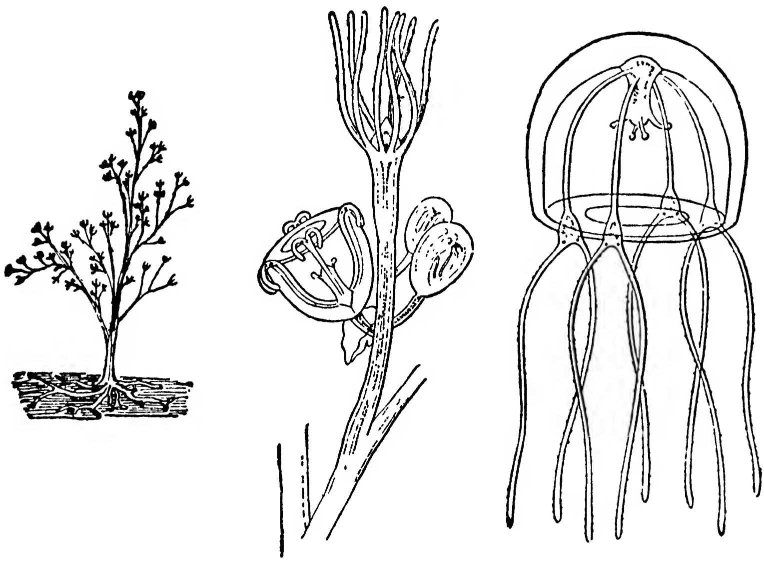
Fig. 60—HELLGRAMITE AND DOBSON FLY

From a drawing by George A. King

A Different Story

Very different is the life history of the Bell

Hydroid shown in Figure 61. The eggs are produced by the Jellyfish shown at *c*, and are cast forth into the sea where they are fertilized, and where they develop into the sessile,* branch-



a b c

Fig. 61—JELLYFISH DEVELOPMENT

a. The branching sessile Hydrant which develops from eggs
b. The Jellyfish developing on a branch
c. The Mature, free-swimming Jellyfish (*Medusa*) which produces eggs

ing Hydranth shown at *a*. Increase in the Hydranth colony is by vegetative division, with new individual zooids (branch animals) at each tip. On the sides of the branches buds grow out which develop into new Jellyfishes. These, when grown, break off and swim away and produce eggs for another generation of Hydranths. The Jellyfish (*Medusa*) reproduces sexually by means of eggs and sperms; the Hydranth asexually by budding. Here we have two forms of an animal, each capable of independent existence and reproduction in more or less regular succession. This is called *alternation of generations.*

* *Sessile,* attached at the base.

CHAPTER VIII

HOW ANIMALS GET ABOUT

WINGS and legs and fins take most animals where they want to go. Winds and floods and chance carriers take them elsewhere sometimes whether they will or no. Wings for the air and fins for the water are the best natural means of transport. After man himself, birds and fishes are the great world travelers. But, unlike man, they travel predetermined routes in their migrations.

MIGRATIONS OF BIRDS, INSECTS, AND FISHES

The migrations of birds are between their summer breeding grounds and their winter feeding grounds. Since they choose

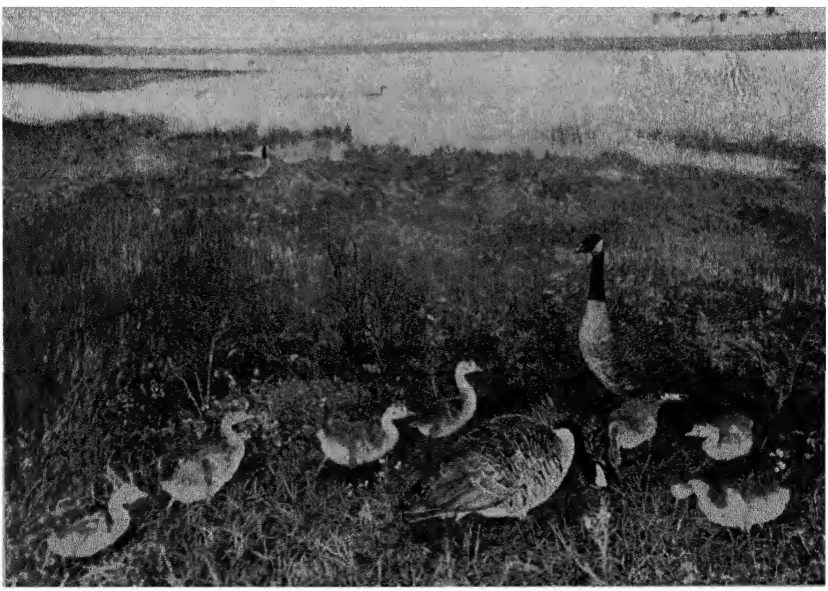


Fig. 62—WILD GEESE ON CRANE LAKE, SASKATCHEWAN, CANADA
From a habitat group in the American Museum of Natural History

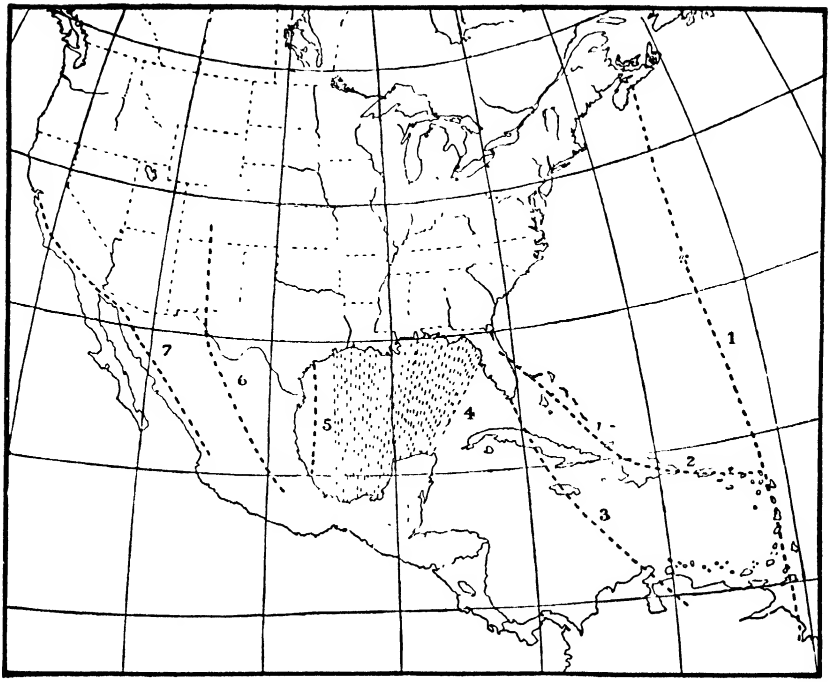


Fig. 63—PRINCIPAL MIGRATION ROUTES OF NORTH AMERICAN BIRDS

Most migrants use route No. 4 though this necessitates a flight of 500 to 700 miles across the Gulf of Mexico. A few traverse the more direct route No. 3, and still fewer, route No. 2. Only water birds make the 2400-mile flight along route No. 1, from Nova Scotia to South America

to breed and rear their young in a land where winter cuts off the food supply, and since they cannot hibernate, they must migrate or starve. Who has not watched the Wild Geese coursing our equinoctial skies in serried V-shaped, honking companies, northward in the spring, southward in the autumn?

Wild Geese, while seeming to wander, come and go between the same or nearby terminal stations year after year. Our little Wrens come back to the same nesting boxes.

Most famous of the feathered migrants, for long distance, is the Golden Plover, which nests within the arctic circle and winters at the tip end of South America, in Patagonia. It is believed that the journey between these places is made in a single flight!

Bird-banding has yielded much information about migration routes and seasons. A number on a light aluminum band placed

on the leg of a trapped wild bird serves to identify it when taken in a new place. Thus individuals are traced as they move about. The hundreds of thousands of records so obtained show that most species follow regular routes and at regular times. In general, those wintering farthest north are first to return southward.

One main-traveled route for the smaller birds that winter in tropical America is directly across the Gulf of Mexico to Yucatan. Another is from the tip of Florida southward across Cuba and Jamaica to Venezuela. Another is farther eastward along the Bahamas and Lesser Antilles to Brazil. There are also several land routes southward through Mexico. In general it may be said that each species which winters in the tropics has its own route of travel and keeps to it.

Most of our migratory seed-eating birds travel less extensively. They do not go southward beyond the Gulf States. Other birds are permanent residents. A Bobwhite may spend its entire life within a few miles of its parental nest.

Insects also migrate, but with less regularity than the birds or the fishes. Most famous of these are the migratory Locusts or Grasshoppers. Apparently it is when they become too populous in their breeding grounds in the dry hills that they set out in swarms to find new pastures in the lowlands. Certain Dragonflies and Butterflies also swarm.

Fishes migrate at the approach of the breeding season. Even our common pond fishes move shoreward to find suitable spawning and nesting places in the shoals. Suckers and Trouts move upstream and spawn among the clean washed stones and gravel in the riffles. Shad and Salmon come in from the sea and swim in hordes far upstream to find suitable spawning grounds. The Quinnat Salmon of the north Pacific coast is the most famous of all fish migrants. At four years of age it comes in from the sea in the spring, enters such streams as the Columbia River in companies that almost fill the waters with fish. It spends the entire summer without food, moving upstream to its spawning grounds in headwater streams which are often a thousand miles or more from the sea. Then it lays its eggs and dies. The young after hatching and feeding for a time in fresh water go down to the sea to complete their growth.

Eels show a curious reversal of this migration. They spend most of their lives in fresh water, and go down to the sea to spawn.

Influence of Climatic Changes

As animals differ in size so also they differ in powers of resistance to the limiting factors of their environment; to heat and cold; to drought and moisture; and to the vicissitudes of climatic changes. Winds and floods and other carriers may bear a species into a new environment, but whether it can maintain itself there will depend upon its own powers.

The Cotton Moth of the South breeds abundantly in the cotton fields throughout the summer; for man assembles cotton plants which are quite to its liking in pure stands* in fields quite to its convenience. He raises these Moths along with the cotton. Then in the early fall comes a dispersal—numberless millions of the Moths fly northward, some of them hundreds of miles beyond the limits of the cotton belt. These are foredoomed to perish for they cannot stand the winter. Climatic factors determine the possible range of a species, within which distribution of water and land determine the possible habitat; while food and protection from enemies and conditions for reproduction determine the actual habitat.

Finding New Locations

Animals which cannot walk or fly or swim have to be carried; for there is no such thing in nature as permanent occupancy of a given spot. A fauna or a flora is as unresting as the sea, though it may have the same permanence of form. Sessile animals, like Sponges and Bryozoans, must move occasionally to new locations, and curious are their devices for getting about.

The Melon Bryozoan (*Pectinatella*) is a curious inanimate-appearing colonial animal, which lives strictly spot-bound during most of its life. It grows in branching form with a living zooid in the tip of each branch, and all the zooids secrete a common substratum of rather solid transparent gelatine. When the

* *Pure stands,* free from other plants.

colony grows around a twig it takes on a melon-shaped form, as shown in Figure 64, with sprays of zooids closely covering the entire surface.

Now how can such a creature get about? When this dead

Fig. 64—THE MELON BRYOZOAN (*Pectinatella*)
From a photograph by Charles McNamara

twig decays, how can it ever find another? When full grown, each zooid of the colony produces a few winter buds (*statoblasts*). These are not eggs, but they are little groups of living cells, that segregate themselves from other tissues and secrete about themselves a protective covering. The old colony then dies and the statoblasts are set adrift in the water.

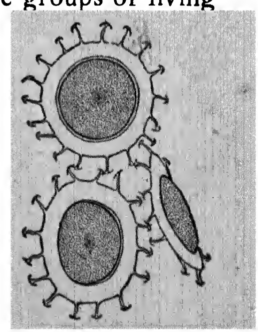


Figure 65
PECTINATELLA STATOBLASTS
From a drawing by Evelyn George

These are the means of dispersal of the species. The protective coat of each statoblast is filled with minute air spaces which serve to keep it afloat and let it drift with the water currents; and if this were not enough, around the margin of each statoblast there is a ring of double hooks, admirably adapting it to "hook a ride" in the feathers of migrating waterfowl. So, among the millions of statoblasts produced on a large "melon" colony, some are likely to find an anchorage where they can rest and grow and form new colonies.

Fresh water Sponges, which are also spot-bound, share in this habit of statoblast formation.

CHAPTER IX

HOW ANIMALS DEFEND THEMSELVES

WEAPONS are the first line of defense. These are very familiar to us in the sharp teeth of a Dog, the claws of a Cat, the horns of Cattle, the heels of a Horse or of a Mule, and the beaks of Birds and Turtles. The Elephant tries to destroy his enemy by tramping him into the earth. The Alligator will defend himself by lashing with his great tail. Animals much smaller than any of these have weapons of extraordinary effectiveness, such as the sting of Bees and Wasps and Scorpions. Any one who on bathing in the ocean has bumped into a Jellyfish and has felt the smart of its stinging filaments, or who has stepped on a Sting-ray, or who has touched an Electric Eel and felt the shock of its discharging batteries, will fully appreciate the diversity of defensive equipment among animals.

WEAPONS FOR DEFENSE AND OFFENSE.

All these, like the weapons of man, may be used for either offense or for defense. There is, however, an equipment that, like armor, serves only for defensive purposes. It is armor pure and simple in the Tortoises and Armadillos, in Snails and Clams, and in hard-shelled Beetles. It may be further elaborated into spines as in the Horned Toad and the Puffing Fish. It may consist chiefly of spines, as in Sea Urchins, and in the Hedge-hogs and Porcupines. The effectiveness

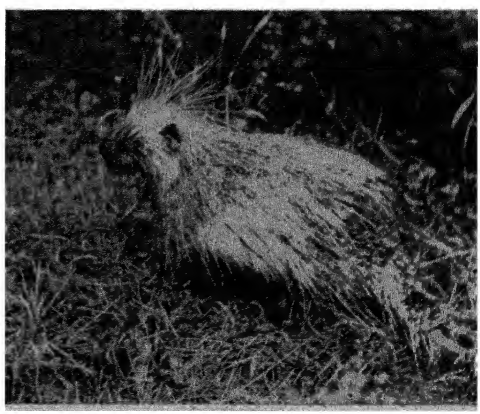


Fig. 66—YELLOW-HAIRED PORCUPINE

of the spines may be enormously increased by adding poison to them, as is done by many spiny and hairy caterpillars.

Projectiles are little developed among animals, and only for

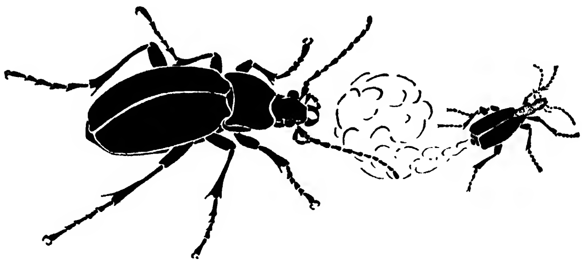


Fig. 67—BOMBARDIER BEETLE ESCAPING BEHIND A GAS CLOUD

From a drawing by Evelyn George

defense. The South American Llama is said to spit when roused to anger. We all know on how slight provocation the Skunk will eject his unsavory secretion in the direction of an enemy and how very effective it is! The Skunk is a past master in the art of chemical defense. So also on a smaller scale are the little Bombardier Beetles, which eject an explosive liquid in the face of a pursuer. It turns to gas and the resulting cloud both halts and bewilders the enemy.

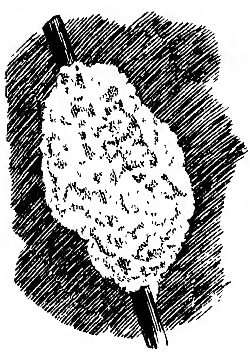


Fig. 68—SPITTLE INSECT

How Insects Defend Themselves

Among insects there are many curious defensive devices. Offensive substances that are not poisonous are used in divers ways. The sluggish, spiny larvae of the Gold Beetles—beautiful shining metallic creatures they are as adults—pile up their own excrement in a broad shield-shaped plate and hold it aloft on the upturned tail-tip like an umbrella over their backs. Underneath this forbidding shelter they escape molestation.

Spittle Insects, which live by sucking the sap from grass stems in the meadow, produce a viscous fluid excrement full of air bubbles and looking like human spittle. This adheres to the

body, flows all around and over the body, and in the midst of a great blob of it the little insect lives in comparative security; and doubtless he lives happily as long as the sap flow is good. With plenty to eat and nothing to frighten him he may well believe that the world was made for Spittle Insects.

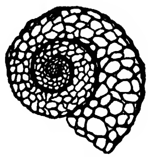


Figure 69

THE SNAIL-LIKE CASE OF A CADDIS-WORM

Defense Armor of Other Insects

Certain animals which lack armor build its equivalent for their own protection. It is not a far cry from the shell growing on the back of a Snail to the spiral case the little Caddis Worm (*Helicopsyche*) makes for itself by cementing together grains of sand. This case was, indeed, first described as a snail-shell by one who was not a good observer.

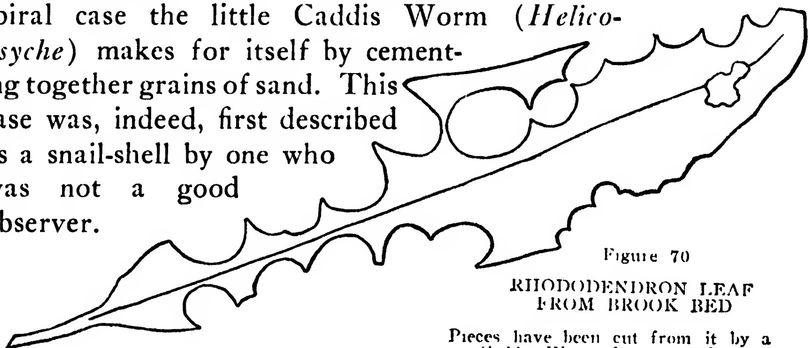


Figure 70

RHODODENDRON LEAF FROM BROOK BED

Pieces have been cut from it by a Caddis Worm for case-making

Most Caddis Worms make straight cases, but they build them out of very diverse materials; sand, stones, sticks, and leaves—each species after its own design. Some place sticks crosswise, some lengthwise. Some add ballast pieces at the sides. The Caddis Worm which lives in the rhododendron-bordered streams of the Great Smoky Mountains cuts pieces out of the dead rhododendron leaves which have fallen into the stream bed, and makes a big case of them which is triangular in cross section.

The Caddis Worm secretes silk which issues from a spinneret in the mouth as a fluid and hardens on contact with the water. This silk is the lining of their cases whatever their form. It is adhesive while fluid and holds together the

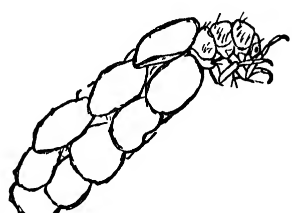


Figure 71

CADDIS WORM WITH CASE MADE OF PIECES CUT FROM A RHODODENDRON LEAF

pieces placed on the outside. Additions are made to the front end of the case as the larva grows.

Similarly the silk of caterpillars hardens on contact with the air, and may be used for case-making, as in the Bagworms, which are larvae of pretty Moths.

Are Animals Fighters?

Most animals do not actively fight their enemies; they merely elude them by some means or other. The Frog when pursued on land jumps into the water, and the Flying Fish when pursued in the sea glides into the air. Squirrels take to their holes in trees, and Gophers to their holes in the ground. Those animals which are neither fleet nor strong nor armored nor agile must depend on strategy. Death-feigning at least looks like strategy, though it is, of course, performed automatically and instinctively in animals. The Opossum on the first onslaught of a powerful enemy falls over limp and apparently lifeless. Thus by yielding, he escapes further punishment, and when his overconfident enemy is looking elsewhere for more Opossums to conquer, he quickly gets up and quietly slips away. So well known is this habit of his that "playing 'possum" is a popular expression for trickery.

Coloration as a Defense

Few animals can afford to be conspicuous. If so, they must be very strong and able to fight, or very swift and able to escape, or very well armored and able to completely withdraw all vulnerable parts from exposure, or very obnoxious and therefore shunned. Protective resemblance is nature's well-nigh universal strategy. Inconspicuousness is chiefly due to coloration, to the matching of the patterns and shadings on the backs of animals to those of their natural environment. The back of the Rabbit is mixed gray, like the dead grass in which it sits. The Katydid, which sits among fresh foliage, is green.

The most nearly universal phenomenon of animal coloration is counter-shading, the dark color of the upper side shading off to lighter below. Light falls unequally on the upper and lower surfaces of the animal. It floods the upper surface while

the lower surface is in the shadow. Counter-shading equalizes this. If any one needs to be convinced of its protective value let him place a specimen of common animal, like a Sparrow, in its natural environment (as on the ground) upside down, and then, looking at it from a little distance, see how conspicuous it becomes.

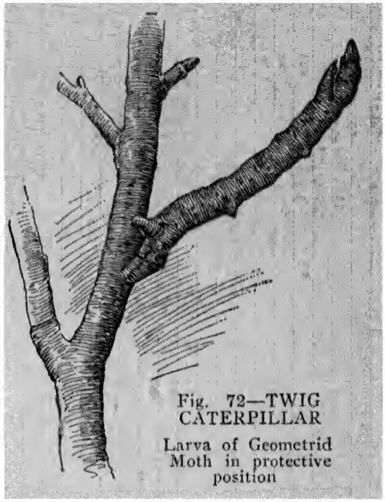


Fig. 72—TWIG CATERPILLAR
Larva of Geometrid Moth in protective position

Nature, as if to demonstrate the value of counter-shading, has turned a few animals over. The Sloth travels upside down, hanging by its immense claws beneath the boughs of trees in the crown of tropical forests. The Back Swimmer (*Notonecta*) swims upside down and so does the little Water Flea (*Scapholeberis*). In all these the belly is dark and counter-shading runs lighter on the back. With reversal of position the coloration is reversed, and conspicuousness is avoided.

Camouflage, a name we learned in wartime, the laying on of colors in such a way as to break up the outline, is common in nature. The white ring around the neck of the Plover has the optical effect of cutting off the bird's head. It breaks up the

Fig. 73—PRAIRIE SHARP-TAILED GROUSE
An excellent example of protective coloration
From a photograph by Herbert K. Job

bird outline into parts which are not very readily recognizable. This needs to be seen in the natural environment to be fully appreciated.

A Leopard Frog on a white plate in the biological laboratory is a very conspicuous object, but when sitting among the weeds by the waterside, its bright spots and blotches of yellow, green, and black fall into place as lights and shadows, and tell no tales of its presence.

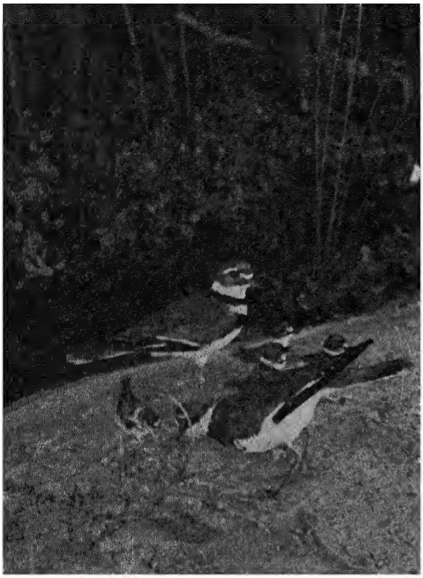


Fig. 74—KILLDEER PLOVER
Detail from a habitat group in the American Museum of Natural History

Flash colors are colors which are intermittently conspicuous when their possessor is in motion, and which are instantly withdrawn from view on coming to rest. They appear to be characteristic of gregarious animals. The white under-tail patches of the Prong-horn Antelope illustrate this; the tail is lifted in running and the white patch is very conspicuous, but when the Antelope stops and drops its tail, all is then of the somber gray color of the apparently uninhabited plain. The white patches on wings and tail of the Junco are flash colors, exposed only in flight. One may watch a flock of these charming little birds fly into a copse of hazel, following their movements with the utmost ease until they settle. Then they instantly vanish from view. The very ease with which they are followed in flight makes their detection more difficult when the marks on which attention has been fixed disappear.

Inconspicuousness is the rule among wild animals, but there are a few exceptions. A few animals, so very disagreeable that others shun them, are saved from unpleasant experimentation by being easily recognized. The Skunk is a fine example of

this. Its colors are black and white. Nothing in nature is more conspicuous. It does not turn from an enemy. Instead it stands its ground, with its tail aloft like a banner in the sky, and its enemies do the running.

Fig. 75—A SKUNK
From a drawing by Evelyn George

Warning colors are laid on in strong contrasts and in broad patterns. They serve to advertise disagreeable qualities —acrid or otherwise offensive secretions in showy Caterpillars and Beetles, bad flavors in certain Butterflies, poison fangs in certain Spiders, stings in Wasps and Bees. Stinging insects are especially easy to see. Their bodies are ringed with black and white and red or yellow. Warning sounds are also manifest in their angry buzzing.

So effective is this advertisement of danger by the Bees that a number of stingless insects have taken on a remarkable likeness to them. This is called *mimicry*. The harmless Robber Fly, a stingless two-winged insect, is so like a Bumblebee that no one would venture to touch it in life without first examining it very carefully. So there are Syrphus Flies which look like Wasps and step out boldly among the flowers with all the confidence of Wasps and buzz loudly in flight. Color, sound, and actions are all in protective accord.

CHAPTER X

FOOD AND SHELTER AND SHIFTS FOR A LIVING

THE primary food of animals is plants and plant products. Animals eat leaves, fruits, tubers, wood, and all other parts of living plants and also the remains of dead plants. They use

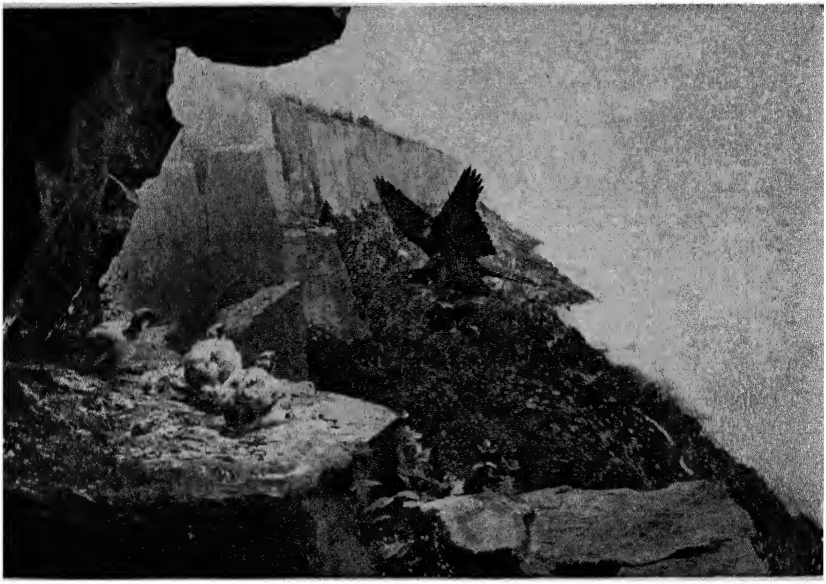


Fig. 76—THE DUCK HAWK
The Gorge on the Palisades, Hudson River
From a habitat group in the American Museum of Natural History

this material for building their own bodies and supplying the energy for their activities. That so large a part of living vegetation escapes being eaten is due to the fact that some animals have taken to eating flesh. The carnivores prevent overproduction of the herbivores, and are themselves held in check by parasites. Herbivores and carnivores, parasites and scavengers, are everywhere, because they fulfill permanent functions in natural society.

We, who roam the earth at will, who forage everywhere, who make over an endless variety of nature's products into edible forms and bring them to our tables from the ends of the earth, have difficulty realizing the narrow bounds that hem in the lesser animals. The Weevil, that must find both house and sustenance within a single seed capsule, and that must strictly adjust its times and seasons to the flowering and fruiting of the plant, is much more typical of animals generally than are we.

Fig. 77—WHITE HERON
From a habitat group in the American Museum of Natural History

When our remote vertebrate ancestors first came up out of the water to dwell on land, they did not at once get up on their feet and walk. They slid around on the mud of the shore on their bellies, using their feet more for propulsion than for support. They were "creeping things," as Salamanders are still. They entered into competition for the rich forage that the land afforded. Some were herbivores and ate the vegetation. Some were carnivores and ate flesh. Some ate both vegetation and flesh. They multiplied and differentiated.

Size determined where they could find a living. A dozen rabbits might fatten where a buffalo would starve.

Competing for a Living

Where to find a living and establish a home was the great problem for all animals, as it is for us today. Food and shelter, and means of escaping enemies were constant needs. Competition for these things developed agility. Land animals got up on their feet and became highly differentiated. Some developed swiftness of foot and could outdistance their enemies. Some developed claws for digging and made for themselves burrows in the ground. Some became climbers and made for themselves nests in the trees. And some developed wings and took to the air.

This last was in the beginning doubtless the best of all ways of escape. Its efficiency is shown by the numerical dominance of the flying species. The flying vertebrates, birds, outnumber all other land vertebrates put together. Flying insects outnumber all other animals put together.

Endurance Counts

But there are other ways of getting on in the world than by entering into continuous competition with the specially gifted. Endurance counts. The ability to hang on, to endure hardness, to tide over a lean season, and so to side-step competitors is often the way of success with animals.

Fig. 78—Woodchucks Hibernating
From a photograph by Silas A. Lothridge

Thus, to avoid competition through the long lean winter season in cold temperate regions many mammals and nearly all cold-blooded animals *hibernate*. To reduce their needs for

oxygen during the lean midsummer season certain Copepods in shallow lakes encyst themselves and lie inactive—they *estivate.* To tide over a rainless period certain Bermuda land Snails seal their shells down to the rocks by means of a copious secretion of mucus which dries and hermetically seals them inside evaporation-proof shelters — they also estivate. To avoid the stress of the arid season when their ponds dry up, Fairy Shrimps and other Phyllopods lay drought-resistant eggs.

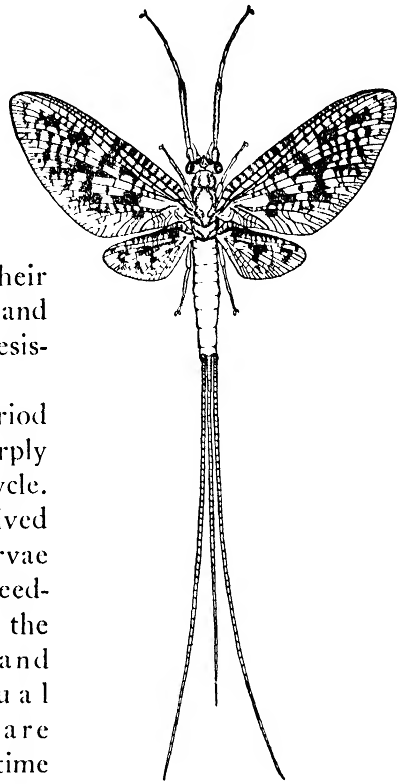


Fig 80—AN ADULT MAYFLY

In many insects growth period and reproductive period are sharply segregated phases of the life cycle. Thus in Mayflies the long-lived aquatic larvae do all the feeding and all the growing, and the sexual products are mature at time of transformation. The short-lived adults have only to mate and lay eggs. They lack jaws and can take no food, and can live at most but a few days. They are weaklings, incapable of competing with other insects, and the struggle for food and place has been almost wholly transferred to the strong and vigorous larvae.

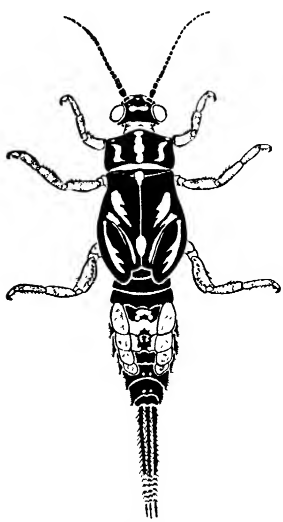


Figure 79
A MAYFLY LARVA

CHAPTER XI

THE WAYS OF ANIMALS

MOST animals are automatons. They are born educated almost to the full extent of their mental capacity. Their nervous organization is such that they must behave in predetermined ways. This behavior is as much a product of evolution as is the form of their bodies. Form and action have evolved together. The mutual workings of the internal organs that have to do with the upkeep of the body are, as with us, perfectly automatic and beyond volitional control. Like us, when hungry they eat, and they digest and use their food quite as we do; it is so also with all the other physiologic processes.

In their instincts, also, in that part of their behavior which has to do with the upkeep of the species, they are automatons, as are we. They differ from us only that their instincts are less subject to volitional guidance. Some of these instincts are selfish or egotistic. That is, they are for self-preservation. They have to do with getting a living; hence the automatic behavior accompanying hunger. They have to do with keeping alive; hence the behavior accompanying fear.

Some instincts are altruistic and have to do with the welfare of others. These are manifest in the love for mates and for offspring, and generally demand a measure of self-sacrifice. Such instincts we share fully with the lower animals. So, also, we share with the social animals in the tribal instincts that are manifest in love of kind. Nature has put first things foremost and has not left the continuance of the species subject to the weak rule of reason.

ANIMALS BORN EDUCATED

With respect to all these things animals are born educated and all the members of a species act alike. But different kinds of animals differ enormously in the organization of their nervous

system, and in their corresponding activities. Even the lowest animals, which lack a nervous system, perform all necessary animal functions and manifest the two basic types of reactions to stimulation—attractions and avoidances.

The Hardshell Clam which lives in the mud of the river bed has only a bit of a ganglion for a brain and its acts are few and simple. It relies on the protection of its armor, and whatever approaches, it closes the valves of its shell. It can do only one thing. Whatever stimulates it, it shuts up. Safety lies in this act. It can neither fight nor run nor hide. It can only shut up and wait for the supposed danger to pass. But then its life is so simple that creeping about in the mud for food and shutting up to avoid danger answer all its needs.

Contrast with this the life of a Squirrel or a Sparrow! But these have brains—brains of the vertebrate type, brains built on the same plan as are our own. With brains of this type there has come the capacity for learning by the individual. In most animals that capacity is exceedingly limited. They do not learn by ordered experiment, reasoning from cause to effect. Indeed they can learn very little by imitation—surprisingly little! They learn, if at all, by the old slow method of *trial and error.*

The Trial and Error Method

"Intelligent" animals acquire their wise ways by the method of trial and error. We may illustrate the method by the colt. He is alone, in a bare lot. He is a social animal, and loves company. He is a healthy animal and sees grass in the nearby pastures. He wants to get out. He knows nothing about gates, but with a gate like the one before him in Figure 81 he may learn how to get out by lifting the bar. What does he do in the process? At first he does everything that a healthy young colt so situated can do. He races around the lot and looks about. He tries to jump the fence and fails. He tries to push it over and fails. He tries various places, the gate among others. He kicks. He stands and whinnies. He bites at the top rail with his teeth. He repeats these ineffective acts, and in the course of his restlessness by chance when standing by the gate he lifts the latch with his teeth, and the gate swings open and he is free. But he has not yet learned. It was an accidental success. When

put back in the lot he begins again and repeats most of the former useless acts. However, he is apt to perform most of them near to the place where he got out the first time, and sooner or later he will seize the latch again and get out a second time.

Thereafter, he will concentrate his efforts near or at the gate, and he will abandon efforts with his heels and with his voice and make more trials with his

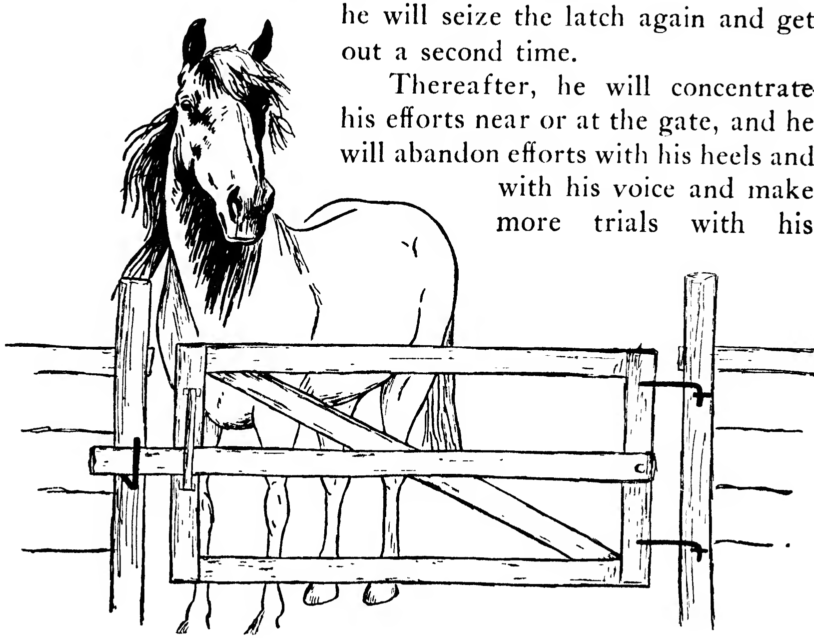


Fig. 81—THE COLT LEARNS TO OPEN THE GATE

teeth. Finally he will have learned where to stand and what to lift in order to get out.

Such is the method of trial and error. It has fairly distinct phases. First there is unrest, with an urge to do something—anything. Then come aimless efforts, all errors, and ineffective. Then comes accidental success. Then follow new efforts, with gradual omission of profitless acts and concentration toward those that bring the desired result.

This is the method by which in infancy we learn to walk, to talk, and to secure attention. It is the only method possible in the beginning. It is almost the sole method available to animals. We learn mainly by imitation (a little also by rational and purposed experimenting), but animals are little imitative. Animals cannot be shown how to do things. The dog which watches his master feed the fire to keep up its grateful warmth,

never attains to the idea of adding a stick himself to keep the fire going.

The training of animals is largely effected by rewards for doing things to suit us, and punishment for things done otherwise. Thus habits are established as with trial and error.

Animal Societies

Society is an aggregate of individuals living together to mutual advantage. Social life is at bottom the life of these individuals, and the character of society is determined by the character of these, its units.

Human society differs from that of animals quite as the capacity of men to learn and to alter their ways differs from the fixed behavior of animals. Human society changes. Animal societies run on the same way forever. Human society is in the main humanly created. Animal societies are predetermined and unalterable.

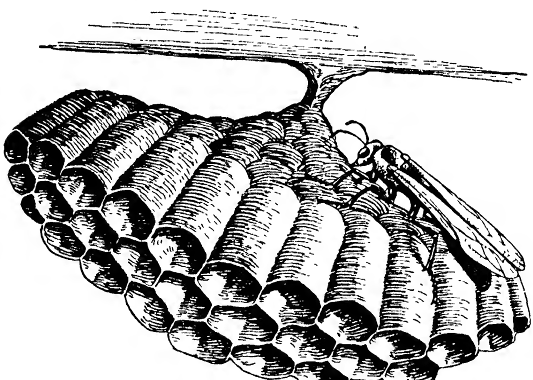


Fig. 82—RUST-COLORED WASP AND COMB

All societies depend for their efficiency on differentiation into classes with divisions of labor, but the only differentiation in our species that nature has imposed upon us is that between the sexes. Our social classes we create. It is quite otherwise with some of the social insects. With Ants and Bees and Termites the social status is predetermined. Individuals are born to be workers or soldiers or members of royalty.

Social Life Among the Termites

Termites, or White Ants, are very important social insects of tropic lands. They build huge domiciles and live in large colonies. They are divided into three principal castes or classes:

1. *Workers.* These are males and females but they are sterile. They perform the labors of the colony. They build the houses and the covered runways leading out therefrom. They gather the food for all the other members of the colony. They remove the wastes and carry the burdens and care for the young and perform all work that is not directly involved in fighting and reproduction. They are the most numerous members of the colony.

2. *Soldiers.* These are males and females, also sterile. Their function is the defense of the colony. They guard the entrances and fight intruders. They accompany the workers whenever their strength is needed either for defense or for aggression, and they form a special bodyguard for the queens. They do not work; they fight. They do not choose this calling, they are born into it. Mother Nature has endowed them with stronger bodies, with powerful mandibles for fighting and with fighting instincts which impel them to the defense of the colony.

3. *Royalty.* These are males and females, "kings" and "queens." They do not work or fight. Their function is reproduction. They develop wings (workers and soldiers are wingless); and when grown they issue forth from the colony in swarms in a mating flight, mingling with the swarms from other colonies.

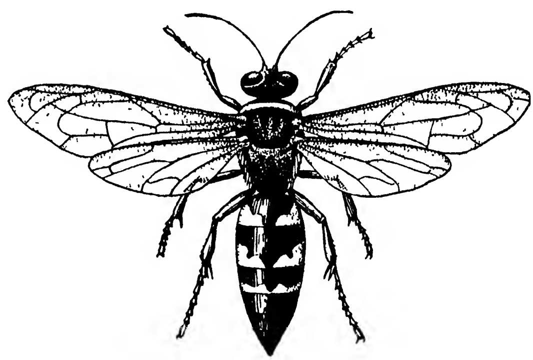


Fig. 83—CICADA-KILLER WASP

The female when fertilized settles down to the business of egg-laying and developing a new colony. She divests herself of wings, these now being superfluous, and remains indoors. She is endowed by nature with extraordinary capacity for egg-laying. She is well fed and groomed and guarded, and has nothing else to do. Her abdomen is stretched to grotesque proportions with its mass of eggs. She soon is lubberly and helpless and unfit for

any other share in the colony. She becomes little more than an animated egg-laying machine.

A Feminine Social System

The societies of ants and bees differ in that they are composed entirely of females, except at the mating season. There may be differentiated castes of numerous workers and big-jawed soldiers, as in some Ants, or the functions of labor and defense may both be performed by the workers, as in the Honeybee; but all these are females. The male sex is restricted to "royalty," and is kept well in hand. Females rule the colony as by an unwritten constitution innate in their nervous mechanism.

In the Honeybee the egg-laying is all done by a single female, called the queen. She is the mother of the colony—not its autocratic ruler. It is a singular fact that in this division of labor the welfare and continuance of the colony has come to depend on a single individual.

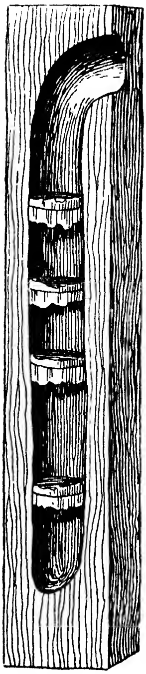


Fig. 84—CARPENTER-WASP AND TUNNEL

The workers are undeveloped females. They are smaller and very active and short-lived. The queen lives a number of years but the workers do not survive a single summer season.

When the honey flow is good and living is easy and the colony is populous the queen bee deposits some eggs in the larger cells toward the outer edge of the honeycomb, and these develop into male bees called drones. The workers then construct a few especially large cells on the edge of the combs and place female-producing eggs in them, and give special care and special food to the young when hatched, and thus prepare for the coming out of a few new queens. Then comes the mating season—the season of swarming. The old queen leaves the hive to seek a new location and a large share of the population of the hive

goes with her. They swarm. They carry a load of honey along and settle in a new place—a hollow tree or an empty hive—and at once begin building new combs and establishing a new colony. The males remain behind with the old colony, where many new workers are emerging and where shortly a new queen will come forth. These drones fly freely about and return to the hive to feed, but they do no labor for the colony. The young queen makes a single flight. She goes forth to meet a consort in the air, and if successful, she returns to the hive to assume the burden of egg-laying and to remain there until the next season of swarming. If there are other young queens about ready to emerge from their cells she stings them to death; for she will tolerate no rivals.

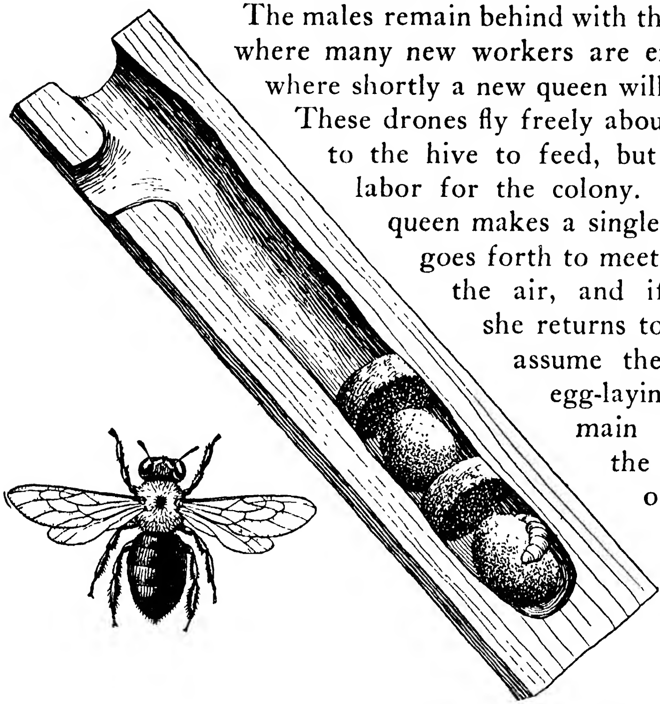


Fig. 85—CARPENTER-BEE AND GALLERY IN SOLID WOOD

If the honey flow slackens, the drones suffer. Being no longer of any use to the colony, and only a drain on its resources, the workers sting them to death and dump their bodies out of the hive.

This is female rule with a vengeance. It is rather unique in the animal world. Its explanation probably lies in the fact that the females only have acquired a sting. Somewhere in the history of the evolution of the group to which Ants, Bees, and Wasps belong (the order *Hymenoptera*) a sharp blade of an ovipositor that had been used for mak-

Figure 86
LEAF-EATING BEE

ing punctures in which to deposit eggs, became transformed into this supremely efficient weapon. And this gift of the gods could go only to the sex that lays eggs.

Caste Among Animals

Ants, Bees, and Termites are the social insects, and these represent the highest development of natural societies. Castes are fully established and these are sometimes more numerous than in the examples we have cited. Each individual is born to his place. There is not space to discuss here some of the industries, such as leaf cutting, fungous growing, slave making, etc., that the worker class of certain species of Ants have. Professor J. H. Comstock expressed the marvel of it in the following words:

> If the statesman or the philosopher would study a perfect communistic society, let him throw away his histories of poor human attempts, and go and study thoroughly the nearest ant-hill. There he will find no love for friend or wife or child, but a love for everyone. There everything is done for the good of the whole, and nothing for the individual. The state makes wars, provides food for all, cares for the children, owns all the property. He will find no complaint against the existing conditions of society, no rebels; but the fate of each one is determined by the accident of birth, and each takes up its work without a murmur. He will find this perfect commune has developed courage, patriotism, loyalty, and never-failing industry; but he will find also that war, pillage, slavery, and an utter disregard of the rights of other communities and individuals are as prevalent as they are among our own nations, where selfish private ambition has held sway so long.

The social vertebrates are only a few birds and mammals. These have progressed only a little way toward social organization. There are no predetermined castes. There is only the differentiation between the sexes by which the males are equipped for fighting (and so may become defenders of the group to which they belong) and the females, for the rearing of the young.

Group Unity

A social order doubtless begins in mere gregariousness: "Birds of a feather flock together." It demands mental capacity equal to grasping the idea of group solidarity and mutual responsibility for the welfare of the group.

Birds, like the Crows, and mammals, like the Baboons, do outpost duty and give warnings of impending danger. They develop a sense of responsibility in leaders, and a sense of de-

Fig. 87—WHITE PELICANS
Klamath Lake, California
From a habitat group in the American Museum of Natural History

pendence on leaders. They may even assume proprietorship of domain. In these things we see foreshadowings of a higher social order.

CHAPTER XII

OUR CHANGED RELATIONS TO WILD LIFE

WEAPONS have given us power to destroy. Even the crudest of weapons when skillfully wielded gave men some power over the brutes. Perhaps this is why the domestication of animals was accomplished so early. Perhaps it was all done before animals had learned the fear of man—before his weapons had slain the gentle and the tamable among them, leaving only the more wary to breed, and to perpetuate their wariness. At any rate, every improvement in weapons has put the wild life farther from us. Animals are quick to learn what is a safe distance. The spear had a greater range of effectiveness than a club; arrows, greater than a spear. Guns using ammunition had so much greater range and efficiency that by their noise and terror they have driven the game beyond the range of all earlier weapons, rendering these forever useless. Guns have indeed become so efficient that their use against animals is strictly limited by law. Their unrestricted use is only permitted in times of war against the ablest of human kind!

Courtesy of Recreation Magazine

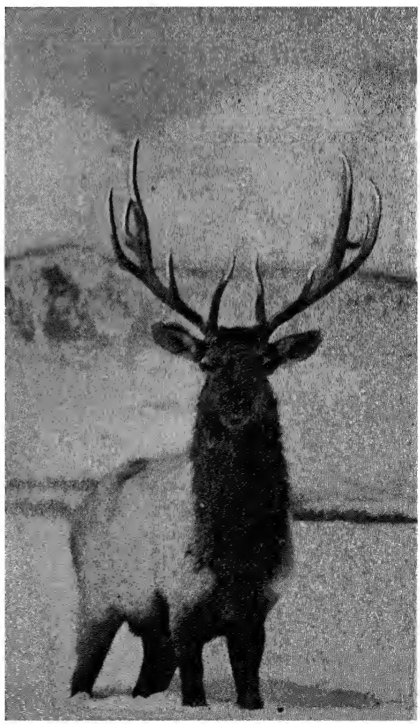


Fig. 88—ELK
Photograph by Bernice L. Linn

other allied forms which cause dysentery. They are animals of the simplest type of organization, corresponding in structure to the free-living Ameba. Their minute size may be imagined

FIG. 89—POLAR BEAR CUB BEING TOWED THROUGH THE WATER BY HIS MOTHER

From a photograph by F. E. Kleinschmidt

from the fact that the Malarial Plasmodium develops within a red corpuscle of the blood.

Though unknown in the past, these doubtless have ever been among man's most dangerous enemies. They do not rend limb from limb, but they bring death—widespread and in most horrible forms. They are not fought with the crude weapons of warfare, but by the careful methods of scientific investigation.

Modern zoology really began with the efforts of certain medieval physicians to learn more about bodily structure and functions in order that they might deal intelligently with sickness and disease. Forbidden to study the structure of the human body, they used the bodies of animals, especially of the mammals most like man in structure. Gradually the range of such studies was extended, and it appeared that the simpler structure of some of the lower vertebrates was illuminating and significant.

Revelations of the Microscope

Then the microscope was brought into service, and the "world of the infinitely small things" was revealed. Of such a wealth of life as was then disclosed the earlier naturalists had never dreamed. The microscope did not at first reveal all that is now common knowledge of the fundamentals of animal life; for men had to learn how to use it, and how to interpret what

The Extermination of Wild Life

The killing of wild animals for food was in primeval times often a matter of necessity. Game was a part of the common dependence for livelihood. Hunting was business, not sport. Later, under agricultural conditions, hunting had merely the aspect of sport, so long as game abounded in apparently inexhaustible supply. But more recently, with the total extermination of some of our fine wild species, and the threatened extinction of others, the indiscriminate killing of wild game takes on a serious aspect. We need to realize that when a wild species has been destroyed it can never be restored. All its beauty, all its interesting behavior, all its fine adaptations, all its possibilities for future usefulness to mankind are gone forever. We are tardily beginning to take measures to conserve a remnant of our wild animals, by establishing reservations for them. Those who come after us may go to these reservations to learn what the native life of their native land was like.

Dangerous Animals

Hardly any change accompanying civilization is greater than that in our relations with dangerous animals. The direct perils of primitive folk were perils of wild beasts—man-eating Tigers, Bears, Wolves, etc. Down to comparatively recent times, these terrorized our ancestors. By the invention of modern guns we have forever removed these ancient alarms. Nowadays we seldom see dangerous beasts except behind iron bars.

But we have exchanged these ancient alarms for others that our ancestors knew not of. Not the largest but the smallest animals are the dangerous enemies of today. They are ever-present, and guns are of no avail against them. They are too small to be seen with the unaided eye. It required another kind of invention to bring these to our knowledge. It was the microscope which revealed these marvelously small animals which live as parasites within our bodies, consuming and disintegrating the tissues and causing disease and death. Their effects were known of old as plagues and pestilences, but themselves only the microscope could reveal.

Such animals are the *Plasmodium* which causes malaria, and

they saw. Gradually cells came to be recognized as the units of structure composing the tissues of all organisms, and protoplasm as the essential living substance composing the cells. Gradually also with the aid of this precious instrument, men were able to unravel the tangled threads of developmental history of animals, and to show their progress from the egg to maturity through simple, orderly changes, that show many common features in all the groups. Thus the unity of life came to be clearly recognized.*

So the interest of mankind in animal life has greatly expanded in modern times. At first it was economic interest, and inasmuch as we shall always need to be fed and clothed, it will ever be largely economic, but it has become more educational. Just as the earlier students of comparative anatomy studied the structure of animals in order to understand the workings of the human body, so investigators of comparative psychology study the behavior of animals in order to understand the workings of the human mind. Body and mind were evolved together, and many fundamental characteristics of both we share with animals. The laws of life are the same for all the living, and in the knowledge of these is involved our own well being.

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* See "The Coming and Evolution of Life" in this *Series*.

CHAPTER XII

HOW TO STUDY ANIMALS

GO WHERE they live and watch them in action if you would know animals. Study their haunts and habits. Go collecting, and gather knowledge as well as specimens—knowledge of where they are and what they do in the world. As Aristotle truly said 1600 years ago, "The essence of an animal is what it does."

The domesticated animals may be observed on a farm; the larger wild animals in the zoo; it is only pets, a few of the smaller vertebrates and such common invertebrates as insects and snails that may be conveniently managed in the home or in the small laboratory. Beetles, snails and tadpoles are everywhere available and may be kept alive in aquaria, in live boxes, or in other handy containers. But he who would keep them successfully must provide for their ever-present needs:

1. Food, of a kind they like to eat;
2. Shelter, in which they can make themselves comfortable;
3. Protection from enemies. How to meet these needs is learned by observing the animals in their natural environment. Clean water for aquatic animals and moist air for terrestrial ones are very important.

Collect and preserve specimens also, and use them as aids to further knowledge—knowledge of their forms and organization, and of their adaptations to place and manner of life. Here we can give only a few suggestions of simple methods for collecting and preserving small animals of the commoner sorts.

Collecting Aquatic Animals

For getting small animals that live in the water an apron net (Figure 90) is best. It is properly shaped for pushing through water weeds. The coarse-meshed cover allows small animals to enter while keeping out the weeds and coarse trash. When the animals are in it, a short push through the water lands them at the rear, where they are easily gotten at by lifting the hinged portion of the cover. The larger ones may then be picked out by hand. The smaller ones are best obtained by dumping the contents of the net into a white dish of water and allowing them to swim out from the trash into view. A lifter that will pick up the most delicate of them easily and without injury may be made from a strip of fine-meshed wire cloth by infolding its edges.

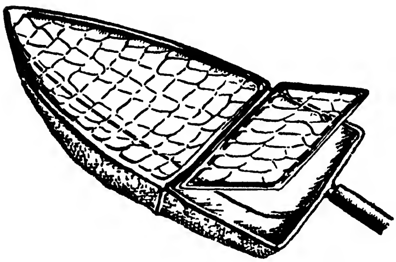

Fig. 90—THE APRON NET

The apron net may be used for scraping up mud or sand from the bottom and sifting it for burrowers and bottom sprawlers. It may also be used in swift water by holding it edgewise to the bottom facing the current, and overturning stones above it, dislodging the insects from shelter beneath the stones. They will be swept by the current into the net.

If no apron net * is available, good collecting from still water may be done with a common garden rake by raking the weeds and the bottom trash ashore and picking it over on the bank, when the animals show themselves by their movement. A small covered pail is useful for carrying home the catch.

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* It is obtainable from Ward's Natural Science Establishment, Inc., Rochester, New York.

Collecting Insects

The general collector of insects, when not seeking to bring his specimens home alive, finds a killing bottle his most indispensable aid. This may be any sort of wide-mouth bottle containing cyanide of potassium or some other quick-acting insecticide. Pulverized potassium cyanide is most commonly used. Mixed with a little dry boracic acid it gives off its fumes readily, and quickly kills the insects placed inside. Thus they are little damaged and make better specimens. The cyanide may be contained in a hollow wooden stopper as in the bottle shown in Figure 91, or it may be placed in the bottom of the bottle and held down there under discs of blotting paper, glued fast at their edges. The bottle should be labeled *POISON*, and kept out of the way of small children.

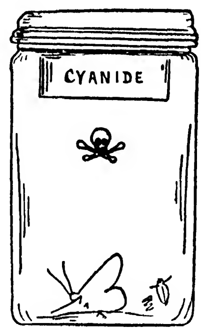

Fig. 91—CYANIDE BOTTLE

With cyanide bottle alone much good collecting may be done, when specimens are not too agile to be picked by hand. Flying insects that swarm about lights on warm summer evenings, ground insects that are found by overturning logs and stones, and many flower- and vegetable-infesting garden insects may be had in this way. The less wary flower-visiting insects also may be pushed from the blossoms into the bottle by deft use of its cork.

Swift-flying insects like butterflies and dragonflies require a net for their capture. It should be large in diameter, light in weight, and strong with open-meshed bag. Nets of various sorts are sold by dealers in entomological supplies.*

A beating net is made with shorter handle and with a bag of stout muslin. It is used for sweeping vegetation to dislodge the insects at rest there. Many of these are protectively colored and will be found only by use of a net.

* Advertised in such journals as *The Canadian Entomologist* and *Entomological News*.

Preserving Specimens

Some animals, mainly adult insects, have the body encased in so hard a shell that they may be dried without great distortion of form or appearance. Such may then be kept mounted on pins, or stored in paper envelopes. Or, if there be only a few choice specimens, and if they are to be frequently handed about, "Riker mounts" may be preferred. These are made by first drying the insects with wings spread and legs and other appendages properly arranged: then placing them on the top of an inch-deep layer of cotton in a shallow exhibition box, putting on the glass cover and with it pressing them down into the loose cotton under the glass, and sealing the box. The cotton will hold them in place. Labels also should go beneath the glass. The box should be about an inch deep and of any desired length and breadth.

Beetles, bugs, and bees and flies are best pinned and require no wing-spreading, but the more delicate butterflies and moths require delicate handling, and the proper spreading of their wings for display is something of an art.

The simplest way of preserving dragonflies, mayflies and ant-lion flies and other such insects is to dry them between loose papers and then place them singly in rectangular cellophane envelopes. These may then be filed edgewise in a box like cards in a drawer. A small label with name, locality and date may be slipped in one end of the envelope.

Museum pests will quickly destroy any dried specimens to which they find access. Therefore specimen boxes of whatever sort should be supplied in the beginning with a thimble-full of paradichlorobenzine * granules enclosed in an envelope of tissue paper, and then sealed tightly to keep them pest proof.

Preservation in alcohol is best for soft animals, alcohol of 70 per cent to 80 per cent strength.

Rearing Insects

For keeping animals alive there are cages in endless variety. The one that will answer most purposes and that at the same

* "PDB" is the popular name of this insecticide under which it is sold at drug stores.

time is cheapest is the pillow cage shown in Figure 92. It is made from a square piece of wire cloth of size and mesh suited to the animals to be retained in it. Two opposite edges of the cloth are brought together, folded over * twice in a tinker's hem, and then, by placing the hands inside, rounded into cylindric form. Then the ends are similarly cross folded and the folds outspread to the form shown in Figure 92. A square yard of window-screen wire cloth makes four cages suitable in size for rearing such insects as dragonflies. At the top of the cage should be a woven edge of wire cloth because the top is opened and closed by hand when introducing or removing specimens and no wire ends should be there to prick the fingers.

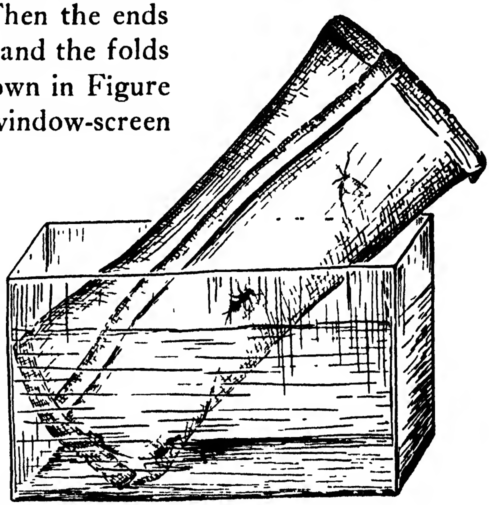

Fig. 92—PILLOW CAGE

For rearing aquatic insects the cage is set in the water as shown, with plenty of space above for wing-spread when the adults emerge. It is set aslant so that if any fall back into the water they may the more easily climb out again, and not be drowned.

For leaf-eating insects this cage may be fitted over a potted plant of the kind used by the insect for food. Galls may be placed inside to await the emergence of the tenants. Wood infested with borers may be encased in a cage made of suitable length to contain the log and left for the emergence of the beetles.

* A small (4-inch) folding tongs is useful but not necessary for making these.

SUGGESTIONS FOR FURTHER READING

Prepared by the Author

THE BOOK OF BIRD LIFE—*Arthur A Allen* VAN NOSTRAND
A study of birds dealing with their relations to environment, their habits, and their relations to man Also gives methods of bird study, particularly in the fields and woods, with living specimens. Beautifully illustrated.

MANUAL FOR THE STUDY OF INSECTS—*J H Comstock* COMSTOCK
The author has devoted a lifetime to the study of insect life, and this manual gives the facts of his knowledge and experience

THE ORIGIN OF SPECIES *Charles Darwin* (Many editions)
A fundamental book for all students of the history, nature, and evolution of life. Opened a new era in biology

REPTILES OF THE WORLD *R L Ditmars* MACMILLAN
A comprehensive work on reptiles of the world.

A REVIEW OF THE PRIMATES— *D G Elliott* AMERICAN MUSEUM
Detailed descriptions of all known apes, monkeys, lemurs, etc., handsomely illustrated.

ORIGIN THROUGH EVOLUTION—*Nathan Fasten* KNOPF
This book is best described in the preface "An attempt to present the facts of evolution as the scientist sees them, in a manner that can be understood not alone by the student, but also by the fair-minded and truth-seeking layman No previous knowledge is assumed on the part of the reader"

BEASTS AND MEN —*Carl Hagenbeck* LONGMANS
An extremely interesting account of the author's experiences for over half a century in dealing in, handling, and taming wild animals Translated from the German by Hugh S R Elliott and A G Thacker

INSECTS INJURIOUS TO THE HOUSEHOLD AND ANNOYING TO MAN—*Glenn W Herrick* MACMILLAN
A discussion of household and other insect pests and practical methods for controlling them Reliable remedies

BUTTERFLY BOOK—*W J Holland* DOUBLEDAY
A book on the butterfly world describing the life-history and anatomy of butterflies, their classification, and the preservation of specimens Well illustrated with colored plates The work is confined to the butterflies of North America

THE EVOLUTION OF ANIMAL INTELLIGENCE—*S J Holmes* HOLT
A comparative survey of the actions and behavior of animals with special reference to the animal intelligence

MAN'S PLACE IN NATURE—*T H Huxley* (Several Editions)
Six essays dealing with the natural history of the man-like apes, relation of man to the lower animals, fossil remains, and methods and results of ethnology

EVOLUTION AND ANIMAL LIFE—*David S Jordan* and *Vernon L Kellogg* APPLETON
An elementary book discussing the life of animals, multiplication, function and structure, birth, growth, development and death, struggle for existence, animal communities and social life, instinct and reason, homes and domestic habits, the special senses, and many other interesting things of the animal world

HANDBOOK OF PROTOZOOLOGY—*Roksabro Kudo* THOMAS
A textbook of unicellular animals, copiously illustrated

THE STORY OF ANIMAL LIFE—*B Lindsay* APPLETON
A small instructive book on animal life containing illustrations of the various classes, diagrams of structure, etc

FIELD BOOK OF INSECTS—*Frank E Lutz* PUTNAM
Reference is made in this book to about 1400 different kinds of insects inhabiting the United States and nearly 600 of these are illustrated in the text, well illustrated.

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GLOSSARY

[Only those terms are defined in this glossary which either are not explained in the text, or are explained once and used again several pages beyond the explanation.]

AMPHIBIAN an animal that lives both on land and in water
ARTHROPODS: invertebrate animals with jointed legs.
CARNIVORES: flesh-eating mammals.
CENTIPEDE: (from the Latin meaning "a hundred feet"), a many legged animal.
CRUSTACEAN: (from the Latin meaning "crust" or "shell"), an arthropod having crust-like shells.
DECAPODS: Crustaceans with ten pairs of feet.
GALLINACEOUS BIRDS: those resembling the domesticated fowls and pheasants.
INVERTEBRATE: an animal that lacks a backbone.
MAMMALS: the highest type of vertebrates, including man and all other animals that nourish their young with milk.
MILLEPEDE: (from the Latin meaning "a thousand feet"), a myriapod with numerous legs or segments.
MOLLUSCS: a branch of the animal kingdom which includes shellfish—oysters, clams, snails, etc.
MYRIAPODS an arthropod with numerous pairs of legs, but with no distinct body regions behind the head.
PRIMATES: the highest order of mammals.
PROTOZOANS· animals consisting of a single cell or a group of cells loosely aggregated.
QUADRUPED: an animal having four feet.
RODENTIA: the gnawing mammals
VERTEBRATE: an animal with a backbone.

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Key to Pronunciation

ā as in dāy	ē as in mēte	ī as in tīme	ŏ as in nŏt
â " " senâte	ê " " êvent	î " " îdea	ô " " lôrd
ă " " ădd	ĕ " " ĕnd	ĭ " " ĭll	
â " " câre	ẽ " " tẽrm	ĩ " " fĩrm	ū " " ūse
			û " " ûnite
ä " " fär	ġ = j (gentile)	ō " " ōld	ŭ " " ŭs
ȧ " " lȧst	ğ as in get	ô " " ôbey	û " " tûrn